Aerocene

CAMPUS READER

HOW CAN WE **HACK** THE ANTHROPOCENE TO CREATE THE AEROCENE?

AEROCENE CAMPUS

SATURDAY 26 NOVEMBER, 2016

9:30am-6:30pm

RCA SENIOR COMMON ROOM
(ENTRANCE FROM JAY MEWS)

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AEROCENE HACK 2

SATURDAY 26 NOVEMBER, 2016
SUNDAY 27 NOVEMBER, 2016

IMPERIAL COLLEGE ADVANCED HACKSPACE

Aerocene Campus will be complemented by a 2-day hack of Aerocene Explorer technology, bringing together scientists, developers, designers, and enthusiasts

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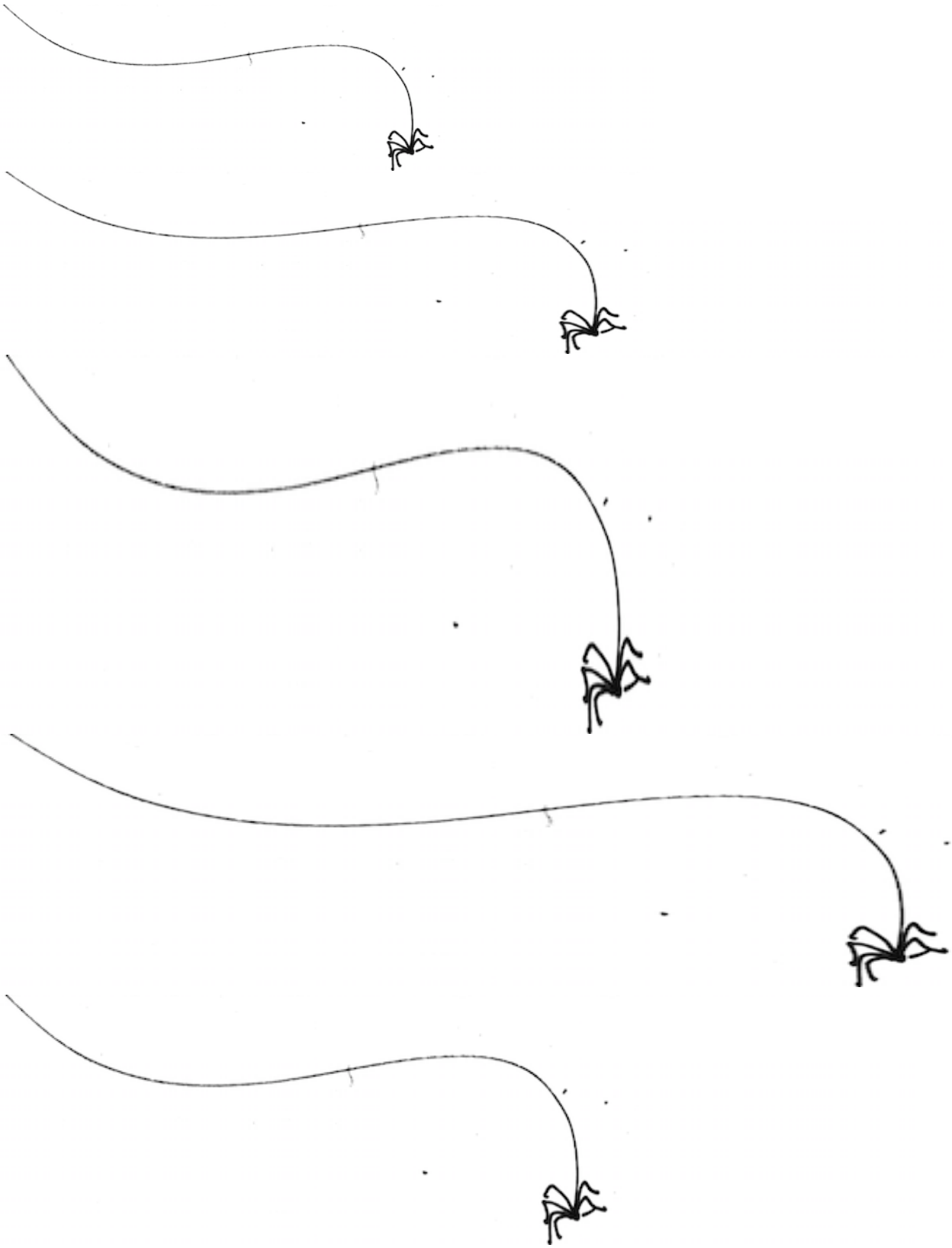

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Aerocene Campus
NOVEMBER 26, 2016 | EXHIBITION ROAD, LONDON

Aerocene comes to Exhibition Road for a multidisciplinary artistic project co-produced by the members of the Exhibition Road Cultural Group, gathering together 17 prestigious cultural and scientific institutions in London, among them, the Serpentine Galleries, Imperial College London, the Natural History Museum, the Science Museum, the Royal Geographical Society, the Victoria and Albert Museum, and the Goethe Institute.
How can we hack the Anthropocene to create the Aerocene?

The first Aerocene Campus is an open invitation to explore, extend and imagine the Aerocene Epoch through the sculpture of the Aerocene Explorer. The Campus asks how community-driven practices with the Aerocene Explorer can inform environmental, social and mental ecologies in post-Anthropocenic worlds. On November 26th, experts from a wide range of disciplines will gather together for a full day of provocation, discussion, collaboration and 'hacking' to experiment with the Aerocene Explorer and to co-create the Aerocene epoch.

To hack is to creatively overcome the limitations of a system, to improve or subvert the intentions of its original form in a spirit of playfulness and exploration. Which geopolitical, social, legal and philosophical "hacks' do we need in order to enter the Aerocene? With this central question, the Aerocene Campus calls upon researchers, scientists, students and activists to address three key Aerocene challenges: Free Flight, Life in the Air and Sounding. These three topics will be introduced on Saturday morning by a panel of experts, provocateurs, reporters and communicators. The campus participants will then select the hacking session which would like to join for the remainder of the day. In the evening, a reporter from each session will present the results for a final large group discussion.
A group of highly technical hackers that have responded to the open call for Aerocene Hack 2 will join the Campus for the introduction and the first working session. Since technical hacks must be supported by the multifaceted worlds in which they exist, we hope these conversations will spark cross disciplinary dialogue between Aerocene Hack 2 and Aerocene Campus participants. Aerocene Hack 2 will continue through Sunday, November 27.

Aerocene Campus Challenges

The Aerocene Explorer, a tethered-flight sculpture currently in beta version, will enable anyone to launch their own personal exploration of the atmosphere. Aerocene Explorer has been developed by Studio Saraceno and a community of collaborators. Each Aerocene Explorer starter kit comes with a small camera, live streaming appliance and sensing devices to record air temperature, humidity, and air pressure. The Explorer allows participants to take aerial photographs and videos, and to collect meteorological data using non-intrusive, emissions-free scientific exploration tools. All the kit's contents are secured in a backpack to ensure portability and comfort when out in the field. The exploration has just begun.

The current state of the Aerocene Explorer will be presented by Sven Steudte and members of Studio Tomás Saraceno on the morning of Saturday November 26th.

I. FREE FLIGHT

Challenge: The challenge of the Free Flight hacking session is to enable the Aerocene Explorer to fly free. In its current state, the Aerocene Explorer is usually attached to a rope anchored to the ground. It flies to a max altitude of 300 metres (the exact height depending on the weather, location and prevailing restrictions). One of the major challenges of the free-flight tests (for example: Gemini 1, 2, 3) is to locate the position of the Explorer's landing. This is vital for retrieving the footage, collecting data and equipment that the Aerocene Explorer carries. Many Aerocene team members and researchers are collaborating on forecasting the Aerocene Explorer's future flights' trajectories. However, the next step is to expand and nuance these tools to simulate the paths of Aerocene Explorers more accurately, and to provide better user engagement options. The Free Flight hack will expand on the Aerocene Hack 1 organised with the Exhibition Road institutions and external collaborators, such as MIT EAPS.
Campus Questions: There are many obstacles to Aerocene Explorer free flight in an anthropocenic era of aviation control and surveillance. How might these structures be surmounted legally, socially and politically? Which petitions, manifestos, commissions and actions are necessary? Aerocene Explorer Free Flight breaks conventional notions of borders and passage. How can today's modes of travel and Aerocene Free Flight coexist? This hack invites practitioners from a variety of disciplines, including design, law, sociology, finance and political theory to engage with the challenge of Free Flight in the Aerocene.

Here is a brief glimpse into the last free flight of Aerocene Explorer.

II. LIFE IN THE AIR

Challenge: In its current design, the Aerocene Explorer carries a series of devices of photography, live streaming, and assessing temperature differences, humidity, and altitude among other factors. The Aerocene residency on Exhibition Road brings an opportunity to develop these sensors further and invent new ones for a better understanding of the airborne ecosystems in different atmospheric strata. Exploring "life in the air" encompasses one of the exciting new directions for collaboration between Aerocene and scientific research on aerial life. With the guidance of experts from the Natural History Museum, hacking groups will design new experiments for enhancing our understanding of aerial biodiversity, and how such biodiversity may be impacted by changing climatic factors. This hack offers working groups the opportunity to adapt the Aerocene Explorer design to accommodate new sampling instruments and technologies, and to target regions of the troposphere and stratosphere, and interconnectivity with the environment at large.

Campus Questions: What is "life in the air" and how can we recognize it? What would it mean to respond ethically to such life in the Aerocene, and over which scales, times and horizons could we attend to it? What is the relation between life in the air and life on Earth? How can we summon a novel collective attention in atmospheric life that breaks from the extractive and polluting logics of the Anthropocene to shape the Aerocene? In these endeavors, critical hacking from humanities, biological and philosophical scholars on what counts as life, death, element, molecule and material is relevant and urgently required.

III. SOUNDING

Challenge: The Sounding hacking session aims to identify applications of sensing, sounding and aerial communication capacities for Aerocene flights and research practices. "Sounding" is the measurement of the physical properties of the atmosphere using surface, airborne or orbiting instruments. The earliest scientific balloon campaigns such as GHOST (although using helium-filled balloons) were experiments in “sounding” the atmosphere of the southern hemisphere through the transmission and reception of signals from unmanned, long-distance stratospheric balloon flights. Whilst the origin of the term "Sounding" has no direct relationship to the sounds of the atmosphere, massive atmospheric events (weather systems, meteorite entry) can be detected or heard at great distances through the propagation of low frequency infrasound. We can also speculate how sonification might provide new insights or a different sensory experience of atmospheric data. The Aerocene Explorer can extend such research through collaboration between atmospheric scientists, Aerocene sculptures, and communities of citizen scientists and aero-acoustic hackers.
Campus Questions: What does the stratosphere sound like? This question might be interpreted in a meteorological or acoustic sense. The key inspirations for various sounding experiments with Aerocene Explorer sculptures might be located in atmospheric science and fluid dynamics as well as musicality, choreography and composition. In addition to modifications to Aerocene Explorers flights, what would need to happen "on the ground" to shift cultural imaginaries of atmosphere as a more-than-visual space and medium? The Aerocene Sounding hacking session invites atmospheric scientists, musicians, music technologists, engineers and social scientists to hack sensory and sonic exploration of the atmosphere.

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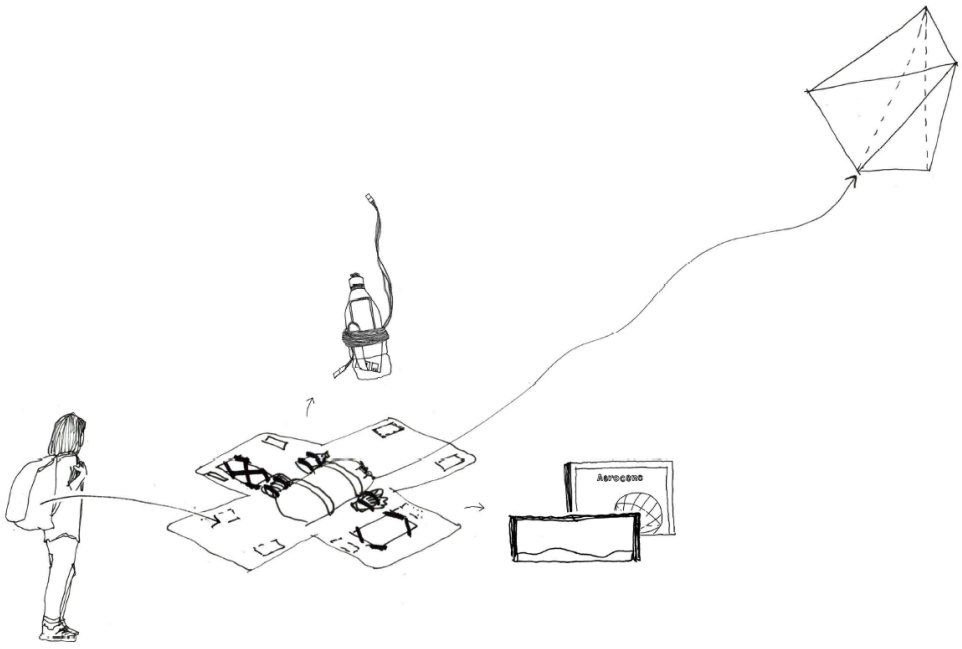
Aerocene’s residency at the Goethe-Institut London as part of the Exhibition Road Commission has been made possible thanks to the support of members of the Exhibition Road Cultural Group, Arts Council England, South Kensington Estates and our Founding Patrons: Francesca von Habsburg, Maja Hoffmann and Nicoletta Fiorucci.



HOW CAN WE **HACK** THE ANTHROPOCENE TO CREATE THE AEROCENE?

ISSUE 32 FIRE WINTER 2008/09

The Cosmonaut of the Erotic Future

AARON SCHUSTER

What happens to levitation, one of the great imaginative figures of art and literature, in the transition from a religious culture to the disenchanted universe of modern science? What becomes of ecstasy, rapture, ascension, transcendence, grace when these give way to "space oddity": man enclosed in a tin can floating far above the world? Is the cosmonaut a prophet of the erotic future, avatar of man's stellar renaissance, as Stanley Kubrick and Arthur C. Clarke once imagined? Or is he like Nietzsche's madman, proclaiming as Gagarin himself was rumored to have said: "I don't see any God up here"?

LEVITATION: WHAT IS IT?The word levitation has several senses and connotations: miraculous, magical, oneiric, but also scientific and technological. Levitation is equally an affair of mystics and engineers, charlatans and poets. One thinks of the feats of the Scottish medium Daniel Dunglas Home, who on 13 December 1868 (one of the most auspicious days in the history of levitation) floated out of a third-story window and returned through the window of an adjoining room; or the ascension of Christ, archetype of all saintly air travel; or the magnetic levitation train zipping commuters between Shanghai and the Pudong International Airport at a maximum speed of 431 kilometers per hour.

Levitation derives from the Latin levitas, meaning lightness. The term would appear to have been coined as the opposite of gravitation, sometime in the early seventeenth century when humanity's conception of the cosmos was being revolutionized by Brahe, Copernicus, and Kepler. Rather than being based on qualitative "elective affinities," the attraction of bodies became a matter of purely quantitative relations expressed by algebraic symbols. Though the ancient cosmology was effectively vanquished by the new clockwork universe, this was hardly a simple or straightforward affair. Even Sir Isaac Newton hedged his bets. While developing his theory of gravitation, Newton was also privately elaborating a highly idiosyncratic theology. According to certain obscure and, until recently, largely neglected writings, after the Apocalypse "children of the resurrection" (notably Newton himself) would be able to levitate at will, soaring "to the furthermost extremities of the universe."[1]

Levitation is also related to levity, to the lighthearted, the frivolous, and the fun. The link between levitation, levity, and laughter was made explicit in the 1964 Walt Disney classic Mary Poppins. (As we'll see, the 1960s was an absolutely crucial decade for levitation.) Near the end of the film, the curmudgeonly bank director miraculously ascends as he goes into hysterics at an employee's little joke. I won't tell you the joke—it's not very good. Later we learn that the old man died. But he died happy from levitating laughter.

PARCELING THE SKYOne of the great literary works of the past century dealing with levitation, combining the technology of aviation with Christian mysticism, is Blaise Cendrars's Le lotissement du ciel (literally "The Parceling of the Sky" but translated as Sky Memoirs). Begun during World War II and published in 1949, Cendrars's book presents a kind of literary collage. Prose poetry, exotic travelogues, personal memoirs, and found texts, including scholarly documents, are all pasted together in a complex construction. Cendrars is renowned as an adventurer, and the stories he recounts here do not disappoint: there is his trip across Siberia with a jewelry merchant, his pilgrimage to a strange Brazilian doctor obsessed with Sarah Bernhardt, his voyage from Rio to Cherbourg with 250 tropical birds (none survive the boat ride), his work as a war correspondent for British headquarters in Paris. But it is the death of his son Rémy, a pilot who perished in the early months of the war, that provides the novel's "center of gravity." Often Cendrars's "parceling of the sky" is interpreted as an act of mourning. He had spoken with his son about the idea of proposing St. Joseph of Copertino, famed levitator, as the patron saint of French aviators. Though Cendrars's plan was foiled by the American air force, which adopted St. Joseph as their own guardian angel in 1943, his fascination for the flying priest was unabated. While hiding from the Gestapo in Aix-en-Provence, he spent his time in the library immersing himself in the study of levitation, and in particular the life of St. Joseph.

Cendrars ends the first part of the book with a passionate proposal to make a film about the levitating saint: "If a producer ever feels like making this prodigious film, I—I, who have sworn never again to waste my time making films—will drop everything, give up my solitude, my tranquility, and my writing, to make this film about St. Joseph of Copertino, in memory of my son, Rémy, the pilot, and as a souvenir for his sometime girlfriend, the out-of-work baker's girl, with whom I lost touch in wartime Paris."[2]

ST. JOSEPH: THE MOVIEWhat might this cinema of levitation have looked like? And what genre would it be? Perhaps an action film? That would certainly fit the temperament of Cendrars, but, frankly, there is not much in the life of the seventeenth-century Italian priest to recommend such an approach. It is true that Joseph's miraculous flights did provoked suspicion, and that he was investigated by the Inquisition at Naples for several weeks. But in the end, Joseph was released after the judges found no demonic wrongdoing. A historical drama, then? Large portions of Cendrars's book are simply transcriptions of the classic 1928 study by Olivier Leroy titled La Lévitation: Contribution historique et critique à l'étude du merveilleux. One could imagine a Duras-style film essay with long shots of airplanes taking off and landing, perhaps an image of a tropical sun floating languidly in the sky, while the voice-over endlessly recites passages from Leroy. Personally, I like to think that it would have been a slapstick-style comedy with lots of physical gags—the unfortunate priest always being lifted off at just the wrong moment, flying away while sitting on the toilet, and so on. There are two details that speak in favor of this conception. First, Joseph was the only saint ever to have succeeded in flying backwards: retrorsum volantem. Cendrars was especially delighted by this fact. Second, Joseph was a total imbecile who (ironically) became the patron saint for candidates for the priesthood and people taking university degrees. So, what we have, in

effect, is a dim-witted backwards-flying priest, a role that would have been perfect for Jerry Lewis in his prime.

In order to envision the appropriate kitsch aesthetics for our hypothetical comedy, we need look no further than The Flying Nun, a highly eccentric television series that ran from 1967 to 1970. No history of levitation would be complete without mentioning this program. The show centered on the adventures of a group of nuns in the Convent San Tanco in Puerto Rico. Sister Bertrille could be counted on to get the nuns out of any jam by virtue of her unexplained ability to fly (perhaps it had to do with the aerodynamics of her oversized hat). Of course the storylines were limited—there are only so many situations one can devise that require the heroine to levitate—and so the show was cancelled after three seasons.

As it happens, a film was made about the life of St. Joseph. It is titled The Reluctant Saint and was released in 1962. The movie was directed by Edward Dmytryk, who is best known for The Caine Mutiny and for being one of the "Hollywood Ten." It is very difficult to get hold of a copy of this film. I have seen it and can report that it is rather conventional and dull. Yet with Ricardo Montalban playing the suspicious Father Raspi, and the great Maximilian Schell in the role of St. Joseph, it is still definitely worth a view.

THE ARTIST LEVITATORI think it would not be terribly controversial to call Yves Klein the artist-levitator of the twentieth century. Indeed, with Klein, levitation becomes a veritable revolutionary program. In his 1959 manifesto Overcoming the Problematics of Art, the artist proclaims: "We shall thus become aerial men. We shall know the forces that pull us upwards to the heavens, to space, to what is both nowhere and everywhere. The terrestrial force of attraction thus mastered, we shall literally levitate into a complete physical and spiritual freedom!"[3]

This ideal, which is simultaneously that of the artist, the artwork, and life itself, is embodied in Klein's iconic photograph The Leap Into the Void; its other, lesser known title is Obsession of Levitation. The artist's audacious plunge is that of a saint announcing the dawn of a new era,[4] an epoch of immateriality where buildings will be fashioned from air currents, color dissolved into the void, and life and art merged in blissful union. In the caption beneath the photograph, it is written: "Today the painter of space must, in fact, go into space to paint, but he must go there without trickery or deception, and not in an airplane, nor by parachute, nor in a rocket: he must go there on his own strength, using an autonomous, individual force; in short, he must be capable of levitation."[5] With his leap, Klein both anticipates the space flight of Yuri Gagarin and outdoes him. The artist is superior to the cosmonaut in that his journey into space is made without the aid of technological gadgetry. Of course, it is ironic that The Leap Into the Void is precisely a doctored photograph, an early and masterful example of image manipulation before the days of Photoshop. As much as it may aspire to "True Life," art, after all, remains a matter of illusion. The photograph was staged on 19 October 1960, with Klein's judo pals holding a blue sheet to catch the levitating artist. It appeared soon after

in the publication Dimanche 27 novembre. Le Journal d'un seul jour (Sunday 27 November: Newspaper of a Single Day).

FAILING TO LEVITATE, OR THE ART OF THE FALLBruce Nauman's photograph Failing to Levitate in the Studio appears six years later as a kind of counter-weight to Klein's ascensional sublimation (sublimation being one of Klein's favorite words). From the triumphant leap of the artist-levitator, always suspected of charlatanry and cheap showmanship, we are presented with the fall of the clown. (Nauman once famously transformed himself into a spitting fountain.) Later, Nauman staged a performance in which two actors were instructed to sink into the floor or, more mysteriously, let the floor rise above them.

If the classical ideal of art is a kind of elevation, lifting up or spiritualization, one way of characterizing contemporary art is as an "art of the fall."[6] Rather than the miraculous flight of the saint, its iconic figure is the well-timed tumble of the slapstick artist. In short: Buster Keaton in place of St. Joseph. I am thinking especially of Bas Jan Ader's Fall films, but there are many failed levitations in recent art history. After hearing about The Leap Into the Void, Paul McCarthy reportedly jumped from his balcony—and broke a leg. There should be a name for this kind of vertiginous mimetic behavior. Perhaps after the Stendhal syndrome, we could call it the Klein syndrome.

PSYCHOANALYZING THE COSMONAUT"The cosmonaut of the erotic future" is a phrase that occurs once, in passing, in the 14 March 1962 session of Lacan's seminar Identification—the same year as the release of the film The Reluctant Saint, almost one year after Yuri Gagarin's space flight aboard Vostok-1 on 12 April 1961, and approximately sixteen months after the appearance of The Leap Into The Void. In other words, a particularly propitious moment in the history of levitation.

How does the analyst interpret Gagarin's voyage? Lacan paints a vivid portrait of the cosmonaut as living pulp implanted in a tin can, quivering flesh plugged into a complex technological apparatus. If for Freud man had already become a "prosthetic God,"[7] in the era of the cosmonaut he would seem to be relegated to a button pusher, utterly dependent on the machine that supports his life functions and extends his limited sensorium. Gagarin himself, together with Soviet psychologist Vladimir Lebedev, stated plainly: "The main function of the operator in the 'man-machine' system, provided it functions normally, is to take the reading of instruments."[8]

For Lacan, the precarious situation of the cosmonaut hooked into an impenetrable mechanism is not an isolated or extreme case, but reveals the universal condition of the human subject. We are all erotic cosmonauts, split between our everyday, phenomenological life experience and the computing apparatus—what Lacan calls the "symbolic order"—that parasites our body and secretly controls our thoughts and desires. The lot of the modern subject, adrift in a universe of significations without substantial support or foundation, is

perfectly encapsulated by "the experience of the cosmonaut: a body that can open and close itself weighing nothing and bearing on nothing."[9]

SPACE SEX At one point during his speculations on the cosmonaut, Lacan raises the delicate matter of the effects of anti-gravitation on sexual desire: "What happens in the state of weightlessness to the sexual drive, which usually manifests itself as going against gravity?"[10] In other words, what happens to male erection in outer space? How can the phallus properly "levitate" in a gravity-free environment?[11] There have been Internet rumors circulating for some time about sexual experiments conducted by NASA and the Russians, but it was popular French science writer Pierre Kohler who first discussed them in print in La Dernière mission: Mir l'aventure humaine(The Last Mission: Mir, The Human Adventure), published in 2000. The chapter titled "Cosmic Love" (in English) begins with a precise scientific question: "Have the astronauts—or the cosmonauts—already made love in outer space? If so, how many of them … and who?" Considering the secrecy of government organizations, we may never know the answer. For the conspiracy-minded, Kohler reports that information regarding the best positions for sexual intercourse in a state of weightlessness is to be found in the NASA dossier STS-75-Experiment no. 8. At the end of the film Moonraker, James Bond floats in amorous embrace with Dr. Holly Goodhead, but this is a highly idealized picture. As Kohler informs us, zero-gravity sex is no easy proposition: best first to strap yourself to your partner.[12]

JEWS IN SPACECompared to the Christians, levitation is not really a Jewish strong point. One can, of course, find some scattered episodes of miraculous flight in the Old Testament, but the phenomenon of levitation, especially as ecstatic experience, is largely absent from the Jewish tradition.[13] There is an important exception to this general neglect: Emmanuel Levinas's reflections on Yuri Gagarin, contained in his short 1961 essay "Heidegger, Gagarin and Us."

What does space flight signify for the Jewish philosopher? The first thing that strikes the eye is the way that Levinas puts Gagarin and Heidegger back to back. Strange comparison: what do the Russian cosmonaut and the rustic thinker of Todtnauberg have to do with one another? In fact, they represent absolute antipodes: Soviet Communism and German Fascism, technological wizardry and technophobic anti-modernism, vita activa and vita contemplativa. Most importantly, for Levinas this impossible couple stands for the choice between "enlightened uprootedness" (enracinement éclairé) and "earthly attachment" (attachement terrestre). By voyaging into space, man leaves behind his mythic homeland: even further, he discovers that this hallowed place was never anything but superstition and idolatry. Levitation makes of the human being a creature of the universe. Against the philosopher of the forest clearing, Levinas defends the astral desires of technological man.

To quote Levinas's remarkable elegy to Gagarin in full:

What is admirable about Gagarin's feat is certainly not his magnificent Luna Park performance which impresses the crowds; it is not the sporting achievement of having gone further than the others and broken the world records for height and speed. What counts more is the probable

opening up of new forms of knowledge and new technological possibilities, Gagarin's personal courage and virtues, the science that made the feat possible, and everything which that in turn assumes in the way of abnegation and sacrifice. But what perhaps counts most of all is that he left the Place. For one hour, man existed beyond any horizon—everything around him was sky or, more exactly, everything was geometrical space. A man existed in the absolute of homogeneous space.[14]

In brief, Gagarin is the ultimate figure of exile: a man without roots in a cosmic desert without horizon or end. Mel Brooks once made a comedy sketch called "Jews in Space," but Levinas goes even further: in the vast expanses of space, we are all wandering Jews.

REMEMBERING HOW TO FLYIn the February 2008 issue of the Journal of Hand Surgery, there appeared an article by Dr. Samuel O. Poore examining the question of whether, through reconstructive surgery, the human arm may be transformed into a functional wing. Can man's ancient dream of unassisted flight finally be realized through cutting-edge surgical techniques? After thoroughly detailing the medical possibilities and problems, the answer finally is no.[15]Yet as a certain literature would have it, the power to fly, far from being a vain aspiration, is a most ordinary and general human capacity. Everyone can fly. Only, we have forgotten how to do so.

The historian of levitation cannot fail to be impressed by the different ways in which levitation is posited as universal destiny. Who is the cosmonaut of the erotic future? Is he the soaring angel of ecstasy that augurs the coming of paradise on earth? Is he the machinic apparatus that parasitizes our body and controls our deepest desires? Or is he the geometric prophet of a new interstellar Diaspora? One of Eugene Ionesco's lesser-known plays, A Stroll in the Air, first performed on 15 December 1962 (a little more than one month after the release of Dmytryk's film on St. Joseph), suggests that salvation lies in reclaiming our innate levitative powers. When Monsieur Bérenger rises into the sky one Sunday afternoon, he explains his behavior to dubious onlookers thus: "Man has a crying need to fly. ... It's as necessary and natural as breathing. ... Everyone knows how to fly. It's an innate gift but everyone forgets."[16] The same sentiment was later echoed in Paul Auster's Mr. Vertigo. At the novel's end, the narrator, once a vaudevillian "Wonder Boy" renowned for his gravity-defying stunts, offers the following simple instructions for levitation:

Deep down, I don't believe it takes any special talent for a person to lift himself off the ground and hover in the air. We all have it in us—every man, woman, and child—and with enough hard work and concentration, every human being is capable of duplicating the feats I accomplished as Walt the Wonder Boy. You must learn to stop yourself. That's where it begins, and everything else follows from that. You must let yourself evaporate. Let your muscles go limp, breathe until you feel your soul pouring out of you, and then shut your eyes. That's how it's done. The emptiness inside your body grows lighter than the air around you. Little by little, you begin to weigh less than nothing. You shut your eyes; you spread your

arms; you let yourself evaporate. And then, little by little, you lift yourself off the ground. Like so.[17]

This essay is adapted from a talk given as part of the night program of the Berlin Biennial ("Mes nuits sont plus belles que vos jours") in the Zeiss Planetarium, Berlin, on 4 May 2008.

1. Frank E. Manuel, The Religion of Isaac Newton (Oxford: Clarendon Press, 1974), p. 102. I also draw here on Joel D. Black, "Levana: Levitation in Jean Paul and Thomas de Quincey," Comparative Literature, vol. 32, no. 1 (Winter 1980), pp. 44–45.
2. Blaise Cendrars, Sky Memoirs, trans. Nina Rootes (New York: Paragon House, 1992), p. 148. The other great writer of the twentieth century fascinated with St. Joseph was Italian playwright and actor Carmelo Bene, who wrote a whole play about the flying priest. For Bene, the most interesting characteristic of St. Joseph was his imbecility—he quips that Joseph was so stupid he didn't even know the law of gravity.
3. Yves Klein, "Overcoming the Problematics of Art," in Overcoming the Problematics of Art, trans. Klaus Ottmann (Putnam, CT: Spring Publications, 2007), p. 64. Translation modified.
4. The suspended pose of the self-defenestrating artist might best be described with the paradoxical expression of an "upwards fall." As Cendrars writes: "The saint who falls into ecstasy falls into the abyss, floats On High, levitates, gyrates in a transport, breaks out, and is no longer in possession of himself. At the most, he lets out a cry or a last sigh. Then he lets himself go and plummets into the very depths of the Word of God. He soars…" See Cendrars, Sky Memoirs, p. 135.
5. Klein, "Selections from 'Dimanche,'" in Overcoming the Problematics of Art, p. 106.
6. See Gérard Wajcman, "Desublimation: An Art of What Falls," Lacanian Ink, no. 29 (Spring 2007).
7. Sigmund Freud, Civilization and Its Discontents, in The Standard Edition of the Complete Psychological Works of Sigmund Freud, trans. James Strachey (London: Hogarth, 1955) vol. 21, pp. 91–92.
8. Yuri Gagarin and Vladimir Lebedev, Psychology and Space, trans. Boris Belitsky (Honolulu: University Press of the Pacific, 2003), p. 259.
9. Jacques Lacan, "Merleau-Ponty: In Memoriam," in Merleau-Ponty and Psychology, ed. Keith Hoeller, trans. Wilfried Ver Eecke and Dirk de Schutter (Atlantic Highlands, NJ: Humanities Press, 1993), p. 74. Translation modified.
10. Lacan, Seminar IX, L'Identification, session of 28 February 1962 (unpublished).
11. For the father of psychoanalysis, the paradigmatic levitating object is the phallus. "The remarkable phenomenon of erection," Freud writes, "around which the human imagination has constantly played, cannot fail to be impressive, involving as it does an apparent suspension of the laws of gravity." The Interpretation of Dreams, in Standard Edition, vol. 5, p. 394. Freud's colleague Victor Tausk adds that erection is first experienced as "an exceptional and mysterious feat," something "independent of the ego, a part of the outer world not completely mastered," and even a kind of "machine subordinated to a foreign will." See "On the Origin of the 'Influencing Machine' in

Schizophrenia," in Sexuality, War, and Schizophrenia: Collected Psychoanalytic Papers, ed. Paul Roazen (New Brunswick, NJ: Transaction, 1991), pp. 213–214.

12. In contrast, in the cinema of Andrei Tarkovsky, levitation always occurs in place of the sexual act. By virtue of its unreal, miraculous character, levitation is apt to convey the miracle of love, which, according to Tarkovsky, is completely obscured by images of copulating bodies. Incidentally, it was another Soviet filmmaker, Pavel Klushantsev, who first filmed zero-gravity space scenes.
13. One should not forget, however, the mystical tradition of Judaism, which includes flying rabbis; see, for example, the floating Jews in Cynthia Ozick's short story "Levitation," or scenes of flight in the paintings of Marc Chagall. Like Judaism, official Islam also de-emphasizes levitation. One of the most interesting treatments of levitation in the Islamic tradition is found in the work of Avicenna, who, some six centuries prior to Descartes, proposed a radical thought experiment to demonstrate the nature of self-consciousness. This experiment, in which a man is imagined deprived of sense data, floating in a void, was later dubbed the "Flying Man."
14. Emmanuel Levinas, "Heidegger, Gagarin and Us" in Difficult Freedom: Essays on Judaism, trans. Seán Hand (Baltimore: Johns Hopkins University Press, 1997), p. 233.
15. Samuel O. Poore, "The Morphological Basis of the Arm-to-Wing Transition," The Journal of Hand Surgery, vol. 33 (February 2008). I thank Darius Miksys for this reference.
16. Eugene Ionesco, "A Stroll in the Air," in Plays, vol. 6, trans. Donald Watson (London: John Calder, 1965), pp. 46–47.
17. Paul Auster, Mr. Vertigo (New York: Penguin, 1994), p. 293.

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The Cosmic Flight of the Aerocene Gemini

Sasha Engelmann

August 27th, 2016. 7am.

52°27'32.4"N 14°03'15.3"E

Schönfeld, Germany.[1]

Forecast: The current weather forecast looks very good (sunny). The wind speed[s] are not that high, so it might no fly so far.

We can only Do-It-Together (DIT)!

Plot your prediction on this map.

The transmission will include APRS position messages including inside and outside temperatures (the lifting power of the balloon), humidity, and air pressure.

Callsign: DL7AD-11
Frequency: 144.800 MHz AFSK1200
Packets: Low-duty.cycle APRS/SSDV images, Position packets, Log packets, Software error log packets (for debugging)
We run a special SSDV/APRS service which picks up the packets from the APRS-Igates and send them to Habhub.

Callsign: DL7AD-11
Frequency: 144.860 MHz 2GFSK9600
Packets: High-duty-cycle APRS/SSDV images
For decoding we run a specific Perl Script which work together with a TH-D72.

We would be interested in any ideas how to improve an open source solar flight predictor.

All images will be plotted on the SSDV page: http://ssdv.habhub.org/DL7AD[2]

Dear Ballooning Friends… [3]

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[1] The message from Studio Saraceno specified: "The location for this launch was selected because it falls outside the air traffic control zone in Berlin, necessary due to local air traffic regulations." (Studio Saraceno, personal communication, 2016).

[2] SSDV stands for "Slow Scan Digital Video" and is a digital form of Slow Scan TeleVision. It can be used to transmit small images along with the telemetry data transmitted by an aerostat's payload during flight. This definition is borrowed from the UK High Altitude Society – "a loose collection of people who are interested in launching unmanned high altitude balloons into near space" (ukhas.org.uk).

[3] Excerpts from an email sent from Studio Saraceno on August 26th, 2016 to "friends of the Aerocene": in the message, people from many disciplines are invited to follow and track the Aerocene Gemini sculpture by accessing web sites and tracking information as it flew from Germany to an unknown location.

A Chase

The Aerocene Gemini (Interstice VII) launched into the air around 7:30am, on a brilliantly sunny Saturday morning in Schönfeld, Germany. There was almost no wind. The sculptures floated a dozen meters high, payloads trailing on ropes below. For some time, nothing happened. The two-part body hung there, like a pair of fragile creatures waiting for change, absorbing the sun's eager rays.[4] "We are relearning how to float in the air," Saraceno said.[5] Then, almost without warning, they caught a draft. A faster current. A line of flight. And they were off, joined together like the ancient twins Castor and Pollux, the Dioscuri, half immortal, bodies whose destinies are fatally joined, making their way steadily toward a line of tall trees in the distance.

This chapter follows the flight and fate of the Aerocene Gemini, tracing a cosmological and aesthetic account of their journey. As they soar through the stratosphere, the Gemini will inspire some final reflections on aesthetics, art and subjectivity as they inflect geographic notions of scale, the more-than-human and the social. The Gemini will also be imaginative companions for speculating on the cosmicity of creative practices. This account is a mythopoietic account, a written experiment conveying the drama of an unusual atmospheric event. In doing so, this essay does not represent the journey of the Gemini as much as collaborate with its retelling as it brings the concerns of this dissertation into a higher current, a common web.

[4] The best description of the *Aerocene Gemini* launch was offered by Kotryna Šlapšinskaitė, a studio member who was present at the event, and related the details to me later that day.

[5] This comment was made three days later at an evening presentation at Studio Saraceno at which Saraceno, Daniel Schulz, Sven Steudte, Thomas X and Nick Shapiro (Public Lab) presented the innovations and experience of this Aerocene Gemini launch.

Figure 1: Detail of image from: Marolles, Michel de, Tableaux du Temple des Muses, Paris, 1655, plate 25.
The plate carries an inscription in Latin from Homer, Odyssey Bk 11, lines 303-4:
One day both Dioscuri live, one day they are both dead.
Photo Warburg Institute.
Courtesy of Warburg Institute.

As studio assistant Kotryna Šlapšinskaitė related to me, the ascent was gentle; Aerocene Gemini approached the tall trees, and as the earthbound humans held their breaths, the sculptures barely cleared the treetops, payloads intact (Šlapšinskaitė, personal communication, 2016; Figure 1). Then they disappeared into blue sky, dissolving into two particles whose presence had been so palpably felt an hour earlier as two membranous bodies hanging motionless over the field, shifting the texture of space-time; two delicate creatures sharing a common filamentary web; two aerosols attracting the assembly of practitioners, technologies, cascades, predictions and hopes in those particular cosmic conditions.

The chase began. A sense of excitement, of thrill, of adventure and equally, of suspense and trepidation. The Dioscuri were no longer immediately sensible, yet they communicated vital signs: they transmitted GPS location data, and readings of temperature, pressure and humidity inside and outside the membranes. They captured and forwarded images of the view from their lofty aerial position to a live website where grounded practitioners could follow along. I was one of these

grounded practitioners, constantly refreshing the SSDV website for new images. In this way my sensory realm was cosmologically extended: it was lured toward pulses of information from those distant, airborne twins, twins whose capacity to pulse such information depended on the ecology of practices that had unfolded at Studio Saraceno and on the morning field. This ecology of practices was structured by legal frameworks: it had been organized to meet the guidelines of weight restriction for an aerostatic object launched in the airspace over Germany.[6] For Tomás Saraceno, the chase team, and many other distant witnesses, Aerocene Gemini became a tiny red icon of a balloon on a map of continental Europe (Figure 2). Yet the conjoined sculptures were not reducible to the icon, since they continued to engender affective atmospheres, imaginative journeys, geopolitical questions, and conversations played out in breathless proximity in the swelter of a hot summer day.

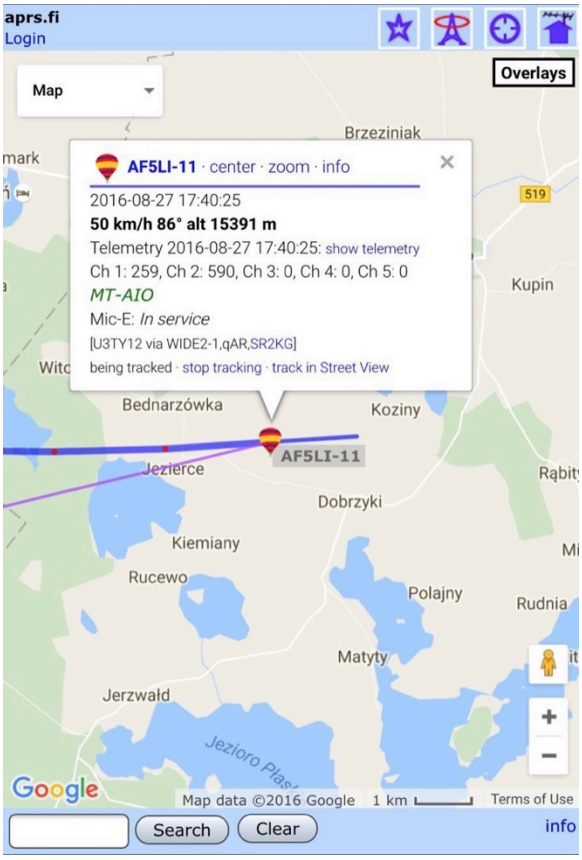


Figure 2: Map of the position of the Aerocene Gemini sculpture at 5:40pm at an altitude of 15,391 meters.

[6] Both Sven Steudte and Thomas Krahn are practiced at the art of launching and chasing balloons via APRS radio transmitters. Indeed there is quite a community of people who do this. It is legal to launch aerostats of a certain weight profile, and even to let them fly with no intention of finding them. However over a certain threshold, the aerostats must be equipped with more advanced transmitters (transponders) and be certified under different insurance schemes.

Tomás Saraceno. Aerocene Gemini, Free Flight, 2016
Courtesy the artist; Pinksummer contemporary art, Genoa; Tanya Bonakdar Gallery, New York; Andersen's Contemporary, Copenhagen, Esther Schipper, Berlin.

Aerocene Gemini reached over 16,000 meters in altitude. The twins crossed the borner of Germany to Poland, having caught a strong Southwesterly wind. At this point, the images loading on the SSDV page were either neon rectangles, or impossibly granular. I later learned that this was not due to altitude or distance, simply to "software error" (Krahn, personal communication, 2016). Where were they going? What were they seeing? Where would they land? Questions surfaced. Sensations of nervousness and worry intensified, caught up in that small red icon, hovering across the map. Was the flight too ambitious? Would the Gemini cross the border to Lithuania, perhaps even Russia? The regulations governing aerostatic flights over Russia were not known. Would there be consequences of the Aerocene Gemini crossing the border?

The Lost Twins

A hopeful morning became a worried evening. The sun had set, therefore the sculptures were surely earthbound in Poland. But the signal was lost. It had faded altogether. The chase team still traversed the dark forests and great lakes of Poland near the province of Augustów. It was likely at that point that the sculptures had fallen into water, irretrievable. The chasers tried desperately to pick up the signal. A chance reception was the last remaining hope.

The far away searching for the sense of the sculpture, the search for a signal pulsing weakly through pine, landform, track, herds of elk, stream, stone and fog, was relayed to those in Berlin via sporadic texts and calls. Bodies formed postures that curled into themselves, or slumped into grass. Attempts to distract, to refocus, to worry a little less. Yet the habit of fixing on the little red balloon on the map, where it had last been sounded. All of this punctuated by animated retellings and glossed-over eyes, imparting how the sculptures had lifted into the air, and the way they had hung, spectre-like, there, until the wind, as in myth, had carried them away.

Many things are lost. Many things find an upward draft out of the lives of creatures and never return again. But there is something particular about the loss of an entity that has woven so tightly into ecologies of practice that enable such adventures in sensing: sensing that engenders investments between humans, nonhumans and airy matter. These are ecologies of practice that inspire collective attachments as powerfully as they invoke collective dreams of how the world and its inhabitants might become. The loss of an entity that is not an entity at all, but a gravitational

attractor, a filamentary web, or a more-than-technical device, is a loss that shakes at the filaments of worlds.

The fates of the Gemini were lost in more ways than one. Scholars attest that the destinies of Castor and Pollux were recounted in the Cypria, an ancient poem that preceded the Iliad, but has long been lost. It is rumoured that one of the Dioscuri was mortal, the other immortal; and that upon Castor's fatal injury, Pollux offered him half his immortality, so that they could remain together, sharing their time between Elysium and Hades. In Homer's Odyssey is the following line: One day both Dioscuri live, one day they are both dead (Homer cited in Morelle, 1655: 25). In any affair, and in death itself, the Gemini are bonded: two bodies matching their ascent in cosmic adventures with wind and sun.

> Circa 11:50pm: a signal emerges. Krell and Krahn hear the sculpture on a hand-held radio receiver. They know they are within 3km. They drive down pitch-dark roads. The signal recedes; they retrace their steps. They turn down another road and the signal grows louder.
>
> Circa 1:18am: the Gemini are found. Krahn had exited the van with the radio antenna, and soon spotted the membrane, slumped over a bush in a field.

This news sparks collective elation. Calls and texts fly among phones at 2am. Some feel intense relief, others pride, and others celebrate into the night. The sculpture is returned via car to Berlin, where it is unfolded at Studio Saraceno. Videos and data are downloaded. Damage is checked. One tiny sensor fell off – probably somewhere over Poland. A few days later, a gathering is called for all friends of the Aerocene to hear a presentation of the event. A dozen enthusiasts and friends, in addition to many members of the studio, attend.

Nick Shapiro, a summertime studio resident and collaborator, has brought his expertise on DIY engineering and open-source licensing to the Aerocene project. Shapiro says his work aims to "re-enchant devices" to allow non-academics to "creatively render" answers and evidence in their environments (Shapiro, personal communication, 2016). Following this, Sven Steudte and Thomas Krahn present the APRS radio transmitters and camera-boards they invented for the Aerocene Gemini. Saraceno interjects often with comments and suggestions. Then Saraceno makes a short presentation of his own. Instead of highlighting the spectacular videos taken from the scultpures in the stratosphere, he speeds through dozens of images showing the long drive to the launch site, the unloading of cars, membranes spread on the field, many smiling faces in various crooked poses, a sunny afternoon at the lake, and a scene of waiting in his apartment, among others. He presents the social-affective texture of the experiment: an equal part of the achievement. What we are really doing here, Saraceno says, is relearning how to float in the air.

We are (re)learning how to float in the air. Just like the phrase, You are all vibrating in the same web, with which this dissertation began, this statement is simple and enigmatic. It is strange and alluring. It begs the question: when did "we" ever float? Perhaps as other forms of life, as bacterial, spore-like, metozoan or amphibian creatures? Saraceno implies that we have lost a collective sense of buoyancy, one that we can re-learn by engaging in atmospheric experiments. And in re-learning this skill, this trait that fell away, we can float ourselves into more alluring futures. The directness of the statement – and the all-encompassing "we" – echoes the tenor of You are all / vibrating in the same web. Together, these two statements manifest part of what is so compelling about Saraceno's practice for geographical thought and experiment, and more broadly, why ecologies of practice reaching for the edges of earthly and cosmic experience are aesthetically, ethically and politically radical. Although they are communicated in words, these poetic statements presuppose nonverbal, nonhuman qualities: web-dwelling and floating. They are enunciations that are not irreducibly human; they emanate from a place beyond human, nonhuman and inorganic distinctions. In light of this, the collective practices of vibrating in the same web, or relearning how to float in the air, are practices founded on sensory extension and amplification that do not remove hierarchy or difference as much as vibrate the threads and interstices among modes of being and becoming. Such sensory extension is ethical in its production of empathy (embodied and otherwise). And it is political in its conjuring of collectives and territories coalescing around the transmission of atmospheric sensing: so many vibrating threads.

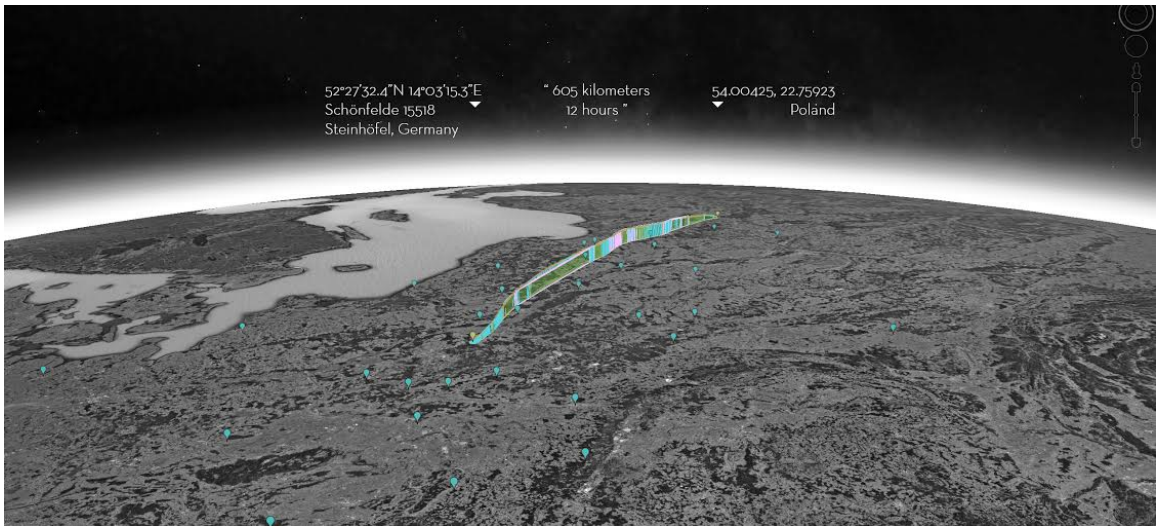


Figure 3: Aerocene Gemini flight path. Tomás Saraceno. Aerocene Gemini, Free Flight, 2016
Courtesy the artist; Pinksummer contemporary art, Genoa; Tanya Bonakdar Gallery, New York; Andersen's Contemporary, Copenhagen, Esther Schipper, Berlin.

Art Ruptures

A specific kind of cosmological aesthetics resonates in the hand-held radio antenna, poised to receive a signal emanating through the thick darkness of the Polish night. Equally it is found in the rough packets of temperature, pressure and image-data transmitting over vast expanses of horizon, atmosphere and landscape in zeros and ones (see Figure 1). And it is also found in the sleepy, strained, and sunburnt bodies of those who launched the sculpture at 7am on a field in Schönfeld, and waited all day for more news of its journey. It exists in all of these places at once because the sounds of the hand-held antenna, the flows of visual data, and the strains in the muscles of practitioners manifest the transmission and distribution of sense and sensing across spaces and scales, from a field in Germany to the stratosphere (Figure 3), yet bound together in an ecology of practices by a common imaginative lure. A lure that is partly localized in the Aerocene Gemini sculptures, but traveling far beyond them, in a body of atmospheric adventures that inspire different stances to matter, energy and environment. Cosmological aesthetics accounts for the role of art and imagination in compelling such adventures in sensing: art is a cosmic force that lures and compels such unlikely ensembles of pracitioners, devices and media.

In doing so, art is a force of rupture and a site where subjectivities emerge and change. As aerodynamic aeromobility reaches astounding levels of growth, and the market for drone technology (both military and recreational) explodes, the launch of an aerostatic, solar-powered object, and the level of investment and commitment it fosters, is a glitch in the interface of the present. Art also ruptures the space-times, scales and social spheres of those invested in the project: compelling strange sleeping hours (e.g. working towards a launch at dawn), enlarging scales of thinking and experiment (e.g. how to track an entity with GPS over an altitude of 10,000 meters?), and producing novel social arrangements (e.g. the congregation of bodies, devices and materials around a delicate, lively membrane). To be sure, other forces also compel these arrangements: forces of economy, profession, friendship, activism, research, thrill, duty, status, obligation, risk and love. However, the imaginative urgency, cosmicity and refrain of the practices discussed in these pages necessitate that we account for the force of art.

In my work I often draw on Guattari's assertation that art creates ruptures, that it generates specific assemblages that present possibilities and potentials in contrast to the assemblages we find all around us (Guattari, 1992/1995). Guattari would likely add that both art and processes of subjectivization become modes of accessing different speeds and velocities of feeling, thinking and becoming. To reprise the last empirical chapter: "the earth [must be] taken into account as a set of

interdependent processes, capable of assemblages that are very different from the ones on which we depend" (Stengers, 2011: 163). The role of art as a rupture from current extractive and fuel-burning assemblages, and a window onto different, inventive assemblages of material collaboration on Earth is, as many have argued, a key to our very survival on this planet (Guattari, 1992/1995; O'Sullivan, 2010). The ruptures created by the launch of an aerosolar sculpture blossom (or fold) into alternative geographic and cosmic subjectivities.

Rather than an achievement in buoyancy and measurement, the launch is a feat of imagination and sensing. This difference matters. It matters because the feat of buoyancy taps into a latent well of poetic reverberation, dynamism, cosmicity, and imagination. This confluence breathes into different modes of being, and into different dreams of the future. Likewise, the Aerocene Gemini does not measure the atmosphere. The sculpture participates in a collective sensing that includes numerous "technical" readings but also, and equally, the data passing and digesting through bodies as the sculpture is launched, tracked, chased, sounded, and rediscovered as an echo on a radio antenna in the night.

Birch Seeds

On August 27th, in the forests of Mostówka, Poland, Dr. Bronislaw Szerszynski was experimenting with some birch seeds (Figure 4). He had collected many over the course of the summer, which he spent, as usual, in a drafty family house, a house I had visited the summer before. This summer, he had invented a series of aerial experiments with the seeds: "They incidentally are a brilliant device… for revealing all the aerial eddies around the house and grounds. One just flew over our water pump and followed the tiny bound vortex leeward of the handle. A very elegant move too" (Szerszynski, personal communication, 2016).

Figure 4: Birch Seeds from the forest of Mostówka. Courtesy of Bronislaw Szerszynksi. Photography by Bronislaw Szerszynski, 2016

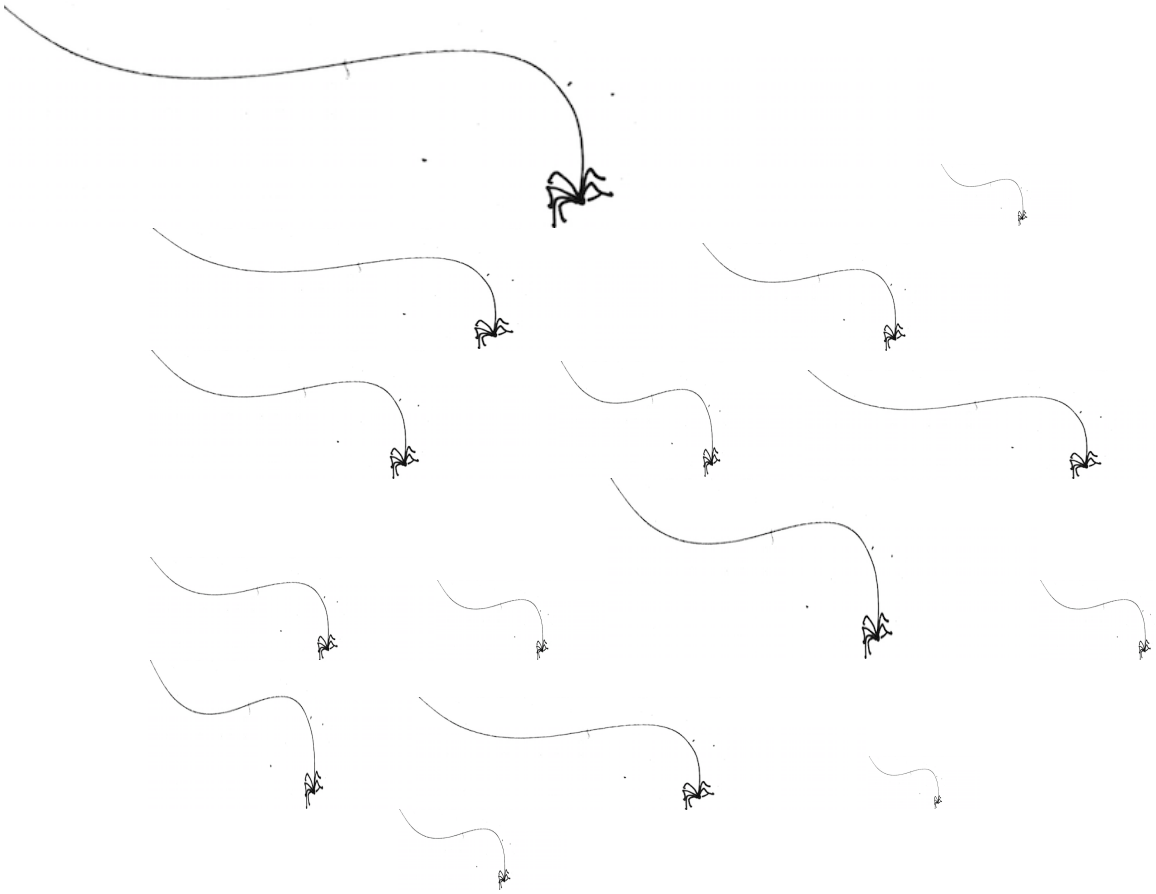
As this seed followed the vortex in the eddies of the forest, were the Aerocene Gemini passing overhead, following so many other vortices and eddies (an elegant move too)? Were the birch seeds and Gemini engaging in the same turbulence, resistance, and the same thermodynamic system? It is impossible to know. But here is another salient speculation: can we think of the Aerocene Gemini and the Birch Seeds in the same web of relations, one that does not produce hierarchies in space or scale, but zones of proximity and synthesis?

On August 27th, Szerszynski was also following the Aerocene Gemini, watching the data and the SSDV image-stream as it passed over Poland and sailed to the North. Like those of us in Germany, he was extending himself cosmologically through the airborne sculpture and the practices and imaginaries enfolded within it, practices and imaginaries of which he was familiar. Indeed, Szerszynski's participation in an aerosolar sculpture workshop at the IAK, TU Braunchweig in November 2014 had inspired a draft paper we wrote together about "elemental dwelling" and aerosolar practices (see Szerszynski and Engelmann, 2015). Whether or not the flight of a Birch Seed was contiguous with that of the Aerocene Gemini is less likely and less relevant than the notion that the aerosolar experiments in which Szerszynski and I participated inspired attentions

and attunements to atmosphere that rippled in various ways in our respective lives and projects. It rippled in the presentations we gave at various conferences, in the "Dust Séance" we performed at the Haus der Kulturen der Welt with Tomás Saraceno, in research questions and conversations with many other people, and in aerial experiments with birch seeds in the forests of Mostówka.

Such ripples of attentiveness – or shifts in atmospheric subjectivity – are aesthetically, ethically and politically important. They shift frames of reference, discipline, labor and invention. They bring the textures of the world to the forefront of scholarship. They propose forms of observation that are ethical in their stance to the patternings of media, materials and phenomena. They convey notions of sense and sensation that are not irreducibly human, nor even within the thresholds of human awareness. These modes of attention and attunement gather publics and polities. Ultimately, the very possibility to tell a story of a balloon and a birch seed in relation to a novel investment in atmosphere implies the web of proximity and synthesis in which they are both entwined.

Figure 5: Tomás Saraceno. Aerocene Gemini, Free Flight, 2016
Courtesy the artist; Pinksummer contemporary art, Genoa; Tanya Bonakdar Gallery, New York; Andersen's Contemporary, Copenhagen, Esther Schipper, Berlin.



Imagine…

Geoaesthetics, a re-imagination of aesthetics for the Anthropocene

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If, as has been claimed, one of the final actions of human agency in the Anthropocene is to render this epochal idea into an aesthetic, then it is perhaps prescient that we consider what kind of aesthetics it is that we might be rendering.[1] How, to expand, might such an aesthetics in its "picturing" "sculpting", "modeling" and "monumentalizing" of the Anthropocene, be equal to some of the challenges, but also seize the opportunities for change, posed by this "big" concept? To explore an aesthetics for this epoch is timely and important; aesthetics can promote sensibilities that enables us to get to grips with those practical and conceptual challenges that Anthropocene raises regarding human's relationship with each other, and the earth. Furthermore aesthetics, as it is formulated here, is also a move for socio-political action, a process for bringing about transformation and change. This speculative essay will propose three geoaesthetic imaginaries fit for the Anthropocene.

Applying the lense of the Anthropocene thesis to the history of art is to find key markers of environmental change –the industrial revolution, land degradation, biodiversity shifts– as not only the subject of, but also the driver for aesthetic revolutions. Such luminaries as JWM Tuner, and Claude Monet, painting during the eighteenth century and nineteenth centuries respectively, create an aesthetics of industrial atmospherics. Even while personally critical of industrialization, their canvases aestheticized industrial development, beautifying pollution in an atmospherics of symbolism and affect that enfolded the energy, dynamism and prosperity of imperial "progress". A century and a half later, and the effects of industry provide a rather more obviously dystopian, aesthetics. Finding form, for example, in the paranoid picturing of plumes of pollution, in the accumulations of waste made glorious in their sheer mass and toxic technicolour,

[1] Mirzoff, N. 2014. 'Visualizing the Anthropocene'. *Public Culture* 26 (2) 213-232.

in the celebration of post-industrial sublimes wherein frames are filled by repetitive grids of buildings stretching beyond the horizon; or in the reworking of the picturesque for a contemporary era by way of the urban ruination of Detroit.

As well as an aesthetic inheritance based in picturing, the industrial processes that have driven the Anthropocene epoch have, fittingly, become the tools of artistic practice. Amongst those competing for the aestheticization of Anthropocene processes *par excellence*, might be the large-scale practices of Land Art's cutting and slashing of the landscape using earth moving machinery, or Bio-art's experiments with synthetic biology and genetic engineering, manufacturing the macabre, the critical and sometimes even the interventionary. What of Nature in all of this? Once the driver of conceptualizations of the sublime –an aesthetic stimulated by the scalar differences between the fragility of man and the inestimable power of natural forces– Nature now seems to have been recast, revalued, reduced even. What we find is a poetics of earth processes based less in awe and power than in preservationist impulses driven by a sense of their all too fragile beauty and precarious existence.

Working across the backdrop of these art works' variegated form and content, this speculative essay explores an understanding of aesthetics that is equal to the challenges raised by the Anthropocene thesis. This is a thesis that requires we revisit many of those concepts that came to characterize modernity, including aesthetics. Amidst the many debates regarding modern aesthetics –comprehended as cognitive judgments of beauty for example, or as embodied sensory experiences, the senses as such constituted through our entanglement with the world– its central figure is that of a disinterested human subject separated from the world they judge or experience. Thinking aesthetics alongside the Anthropocene's overturning of binaries (principally here subject/object and human culture/nature) demands a rather radical re-visitation of the key tenants of the idea of aesthetics itself, to ask what kind of aesthetics, of and for whom?

If geology has been the birth-place of the Anthropocene thesis, the three principles for a geoaesthetics outlined here take up alternative "geo" logics. The earth, atmosphere and its forces are indeed important, but alongside these are imaginaries of the "geo" inherited from geography. These disciplinary bequests require a rethinking of distance and scale in our comprehensions of aesthetics, as well as that we reconsider who and what aesthetics

is of and for. Not only does such a re-imagined aesthetics begin to meet the conceptual challenges that the Anthropocene thesis poses to modern ideas of aesthetics, more than this, it exceeds them in the proposition of an aesthetics that steers us toward transformative action.

Imaginary one: Geo-socialising Anthropocene Aesthetics

Imagine an aesthetics that included non-humans and in-human forces, not only as aesthetic subjects, but which realized their agency as constitutive of aesthetics itself, and even as having their own aesthetics.

One of the primary geo-logics of the Anthropocene epoch has been its unsettling of the binary between nature and human culture. The "social" of the Anthropocene is a resolutely more than human social, encompassing not just non-human animals that are "big like us", but also the microscopic socials of bacteria and viruses. The Anthropocene thesis has prompted further expansion of this more-than-human liveliness to include "geo-social", those geological and atmospheric forces whose operations exceed the temporal and spatial scales of human life.[2]

The forces asserted by the idea of the geo-social are those that constitute the visual vocabularies of the 19th century sublime, with its storehouse of wind-swept waste lands, precipitous glacial gorges filled with swirling snow, and the sulpherous light shows of magmatic events. Despite such pictorial concerns, the Enlightenment evolution of aesthetics rendered it a very human-centric concept; nature might be a subject of aesthetics, but aesthetics is "for" humans. In the face of the Anthropocene's expanded socials, what we require is an aesthetics that enables modes of existence attuned to the enormous tangle of biophysical relationships that constitute the world.

To geo-socialise aesthetics, is not just to take account of the geosocial as the site and subject of aesthetics, but also to reflect on what in might mean to think aesthetics beyond the confines of human meanings and culture. This grants to inhuman forces – vital powers of life, forces of the earth, currents of the atmosphere – an originary,

[2]See for example Clark, N. 2011. *Inhuman Nature: Sociable Life on a Dynamic Planet*. London: Sage.

constitutive role in aesthetics.[3] This is to remove sensation and experience from their primary residence in the phenomenological body, and to locate them abroad in the world, constituted by intensity, pulses, rhythms, refrains. Such distributions raise questions around what it might mean to detail a post-human aesthetics; an aesthetics that exceeds nature as aesthetic subject and generative force to think about aesthetics as a force in the lives and operations of non-humans. To elaborate on such an aesthetics is to rework the terms of aesthetics; exploring other images of cognition, and composing varied understandings of sensation and experience. Such distributed, affect based accounts of aesthetics undo the ontological privilege of being human, to extend aesthetic experience to encompass all subjects, whether they be, a dog, a tree, a mushroom, or a grain of sand, the displays and arrangements of Poster Fish and Bower Birds, or the mineralogy of thromobilites, so called "living rocks."[4]

To think about aesthetics of and for the non-human is a move with significant political and ethical potential. It is not enough merely to note the geo-social, to observe sensibilities that attune us to our being in-common with nonhumans and inhuman forces, although this is a good start. What is required is that we find innovative and creative ways of inviting ourselves and others into such aesthetic relationships, liaisons that deny domination and explore mutuality and interdependence. This brings us to our second imaginary.

Imaginary two: distancing, spacing, entangling

Imagine an aesthetics that replaced the figure of the distanced, dis-interested subject, making aesthetic judgments about a passive world, with an aesthetics that was premised on entanglement and co-constitution.

Kantian aesthetics presents us with an aesthetics based on the disinterested observer, a subject who is separated, distanced, from the objects and world that they are looking upon and judging. As such, pleasure taken or beauty perceived is rooted in the subject

[3] See for example Deleuze, G. and Guattari, F. 1988. *A Thousand Plateaus: Capitalism and schizophrenia*. London: Bloomsbury Publishing; Grosz, E. A. 2008. *Chaos, Territory, Art: Deleuze and the Framing of the Earth*. New York: Duke University Press.

[4] Dixon, D. Hawkins, H. and Straughan, L. 2012. 'Of Human Birds and Living Rocks: Remaking Aesthetics for Post-Human Worlds' *Dialogues in Human Geography*. 2 (3) 249-270.

and their faculties, they are thus not only distanced, but also disinterested and unengaged, autonomous. Such a figure of aesthetics, based as it is in a separation, a distancing of subject and world, shares routes with those Enlightenment epistemologies that vision the world as passive, as ripe for expansion and conquest, a world out there for humans to go and colonize.

The disinterested aesthetic subject of modern aesthetics reproduces the hyper-separation and hyper-incommensurability that is deeply implicated in the socio-environmental crisis that engulfs our planet. The advent of the Anthropocene forcefully reminds us of the folly of such a world-view, indeed one of the hallmarks of critical Anthropocene research and practice is a need, and a will, to replace evocations and performances of humans separated from the earth, as masterful over it, with imaginaries of connectedness. Concerns for extensive distance have been replaced with intensities, and instead of a separation, a distancing between subject and world, entanglements and connections are foregrounded.

A key principal of a geoaesthetics is the replacement of an imagination of aesthetics based on distancing with one based on proximity, intimacy and entanglement. Aesthetic experience is thus not the preserve of an unengaged Kantian spectator, but rather is a process that plays out *between* subject and object. In these terms, aesthetic experience exists only as a relation, as a process that involves both subject and object and cannot be attributed to any of these entities alone. Seeking a way to think about such intermingling and entanglement we might alight on thinking about aesthetic atmospheres. Such atmospherics render aesthetics volumetric, foregrounding relationality, materiality and the spatiality of distributed bodies and forces; human, non-human and in-human. Aesthetics thus becomes both premised on, and a means to explore, the minglings of the world, to encourage considerations of encounters that reinforce presence through joyful co-constitutions, or consider the constitutive role of absence, through loss and estrangement.[5]

Imaginary three: De-Scaling the Anthropocene?

[5] Hawkins, H and Straughan, E. eds. 2015. *Geographical Aesthetics*. Ashgate: Surrey.

Imagine responses to the Anthropocene that did not begin from a logics of "big" problems, "big" science, or have to grapple with the discourses of "globe" talk. Think, instead about politio-ethical action for the Anthropocene that begins from evolving, immanent sets of connections: thinking and doing with others.

The sublime is a grand game of scales, at its root is the tension that crackles across the gap between the smallness and fragility of humans in the face of the unintelligible vastness of natural forces and processes. The logics of the Anthropocene play with the sublime, on the one hand it is a big thing, literally, massively scaled environmental change, a complex global entity, on the other hand, the Anthropocene situates the human force as a central agentive force.

Scale is no small matter when it comes to the Anthropocene. The epoch's dominant spatial imaginary, enabling researchers, artists, and others to comprehend explain and confront it, is that of the global. To raise social processes, to elevate human effects, to the global geologic scale, challenges our understandings of human-environment relations and the politics that propagate from them. It is also to situate humans collectivity, as a unified humanity, on the level with "big" earth surface phenomena and processes that girdle the globe; so ocean currents, atmospheric circulations, geologic forces. To combat this we are enjoined to "think big," to evolve super-disciplines, big problems require big solutions.

In all its 'globe talk' the Anthropocene thesis takes the risky step of reproducing the scaffold imaginary of scale that rests on the global-local binary and its collapse into the powerful–powerless binary. Thus we witness large-scale global forces, with their narratives of universalism and macro-level structures reigning supreme over local knowledge, the particular and everyday, and grassroots, progressive interventions.[6] This is not merely a matter of perspectives, or to question the undeniable importance of "big science;" globe talk is grossly unfair. In unifying humans it blinds us to difference, turning us away from the differential origins and importantly the effects of the Anthropocene. To critically reflect on globe-talk matters because, ironically, it reproduces fixity and works with pre-set social relations, stripping out the multiplicity, hybridity, permeability and contingency that have underpinned thinking and acting in the

[6] See for a discussion the ongoing debates about scale within geography, e.g Marston, S.A. Jones, J.P. and Woodward, K. 2005. 'Human Geography without Scale'. *Transactions of the Institute of British Geographers.* 30 (4) 416-432.

Anthropocene. Finally, and crucially, it matters that we take on global Anthropocene imaginaries because to circumscribe the epoch within the remit of the global is to close-down possibilities for politics, to pre-assign a register for resistance, in other words to assume that effective action can only happen on a global level.

Of course, solutions to socio-environmental crises come in all shapes, spaces and scales, propagating from that space closest in –the body– to the landscapes and environments, and the local communities (human and non-human) that matter to us. To begin with what we witness on the ground, is to assert, as with capitalism before, that there is power in situated local thinking. But yet, attuning to the political effectively of the local, whilst to be celebrated, is not to actually challenge the hegemonic force of global narratives.

How might then we get round the stultifying logics of these scalar debates? One solution might be to think of an Anthropocene without scale. In place of an Anthropocene that is too big, too diverse, presenting challenges beyond our capacities, we begin from where we are and what we can do. We can work with humans and objects and their interactions across a multiplicity of social sites, looking sideways rather than up. We can engage with the place where things happen, things that are contingent, fragmented and changeable, and we can refuse claims or processes that rely upon transcendent social categories. Instead of carving up the world into manageable object types, this is to be concerned with unfolding states of affairs in which situations are constituted as singularities, as collectives of bodies, things, objects, events, doings and sayings.[7] This is to focus attention on locations, where we are now, rather than being always concerned with looking up-there or over-here to find understanding, and to locate sites for action and change.

Going forward

The three imaginaries for a geoaesthetics proposed here develop Anthropocene sensibilities of situated doings and sayings that are premised on constitutive connections and entanglements with non-human others and inhuman forces, as well as a sense of

[7] See for example discussions of human geography without scale: Woodward, K, Jones, JP and Marston, S. 2010. 'Of Eagles and Flies: Orientations towards the Site.' *Area* 42 (3) 271-280.

distributed agency. As such, aesthetics emerges as that which no longer resides in an object itself, but between the relations between subjects and objects.

Attempts though to attune us to these sensibilities is not enough, we need to move beyond visualizing connections and thinking about entanglements to actually bringing them about. Further, we need to consider the sorts of relations, institutions and knowledge making practices that might concretize these sorts of sensibilities. Such forms of geoaesthetics as those proposed here attune us to multiplicity, to being-in-common or being-together, it is an aesthetics that might offer multiple and diverse capacities for political action that enroll new groups (not only the human), new voices, and new potentialities into the political project.

The Floating Ear: Aero-Acoustic Emissions and Perception
Samuel Hertz

Much of the important research and compositions of the composer Maryanne Amacher direct one's attention inward to the mechanical and psychological properties of perception. Through the arrangement of sound works taking advantage of the natural phenomena known as *otoacoustic emissions* (propogative inner-ear vibrations), Amacher eloquently demonstrates the physical creative capacities of the body; outside any aspect of the psychological/subjective dimension of perception, Amacher's works situate the listener in a physically generative position – their ears create novel sonic content within the projected sonic stream. The relationship between the object doing the listening and the object producing the sound, therefore, is instantiated within a more complex space than historically assumed.[1]

Discussing Amacher's otoacoustic works, Gascia Ouzounian expands on the extent to which when "sound, body, and space meet, new dimensions of, and sensitivities towards, environments can be engaged, and our relationship to these and to ourselves and each other within these can be re-imagined and transformed."[2] Hearing is an environmental mapping – the translation of vibratory trajectories, reflections, and transductions. Amacher's work and Ouzounian's reflexive schema of embodied perception and integration suggest even more intimate and affinitive relationships with external environments: not only is one's perception of sound determined in passing through a nexus of noise, architecture, and non-linearity, but simultaneously there is a sense in which one extends outward *into* the space of perception. Further, we should imagine this proposition as a de-centering of the human as a closed hearing mechanism, replaced with a conceptualization of the body and the space of perception itself as fluid and porous. Our thoughts and feelings begin to extend farther . . .

In his description of Tomas Saraceno's *Aerocene* project, Bronislaw Szerszynski remarks that the

> *Aerocene* vision is about *going* up, but also about *opening* up [. . .] and the open body of the *Aerocene* reminds us of the openness of our *own* bodies – that living things, like all dissipative system, depend on a constant flow of energy, matter and information across the boundary that at once divides and joins them and their environment. *Aerocene* points towards an anthropic transition that would open us up to the more-than-human world.[3]

What both Saraceno and Amacher point to is the need to re-evaluate modes of engagement, sensation, and transmission within this open environment. The trajectories of Aerocene aesthetics and otoacoustic emissions accentuate acts of collaboration between human and environmental actors, positing constant translations and transductions across the surfaces on which they intersect.

I propose the idea of "aero-acoustic arts" to denote equilibrium within objects between the creative capacities of sensation and communication. The ear's faculty of sensual topology and temporality within the event-space of perception is a model for a new relationship to aesthetics in the context of Saraceno's Aerocene; below, I offer some speculative visions and imaginative states for the extension of the sonic arts into the realm of the Aerocene.

Great acknowledgement for the context and propositional model of some of the following thoughts is due to David Rosenboom's 2003 publication *Collapsing Distinction: Interacting within Fields of Intelligence on Interstellar Scales and Parallel Musical Models* and Anja Kanngieser's 2015 article "Geopolitics and the Anthropocene: Five Propositions for Sound."

INVITATION I: DEGREES OF FREEDOM

> *Aerocene implies a new relationship to spatial dimensions in the positing of the dispersion of energies in a multi-path system in place of a specific trajectory. Sound will behave quite differently in this new experiential paradigm: new physical opportunities and limits of sonic propagation, as well as new cognitive knowledge and perception.*

How might one understand boundaries in the Aerocene position?

And what new boundaries might exist: Clouds, Pressure, Jet Streams . . .
Will the acoustic qualia of a room become less important than that of a certain day? Than that of a certain altitude?

> *We may imagine sonic arts made audible not* in spite of *air, but in collaboration with it. A different sort of collaboration than the physical fact of sounding by way of air – this is the context of the sounding in air: the unique opportunities afforded by the aerosolar position of the listener.*

INVITATION II: AERO-ACOUSTIC ARTS

> *As our bodies extend outward and find the space of perception to be somewhere in between Sensual Topology and Sensual Temporality (no longer* within*), we might imagine that the position of Hearing is in fact no position at all – it is, instead, its own system of dispersion and reflection. It is Mobile Hearing.*

What is our position? Where are our ears?

To accept Mobile Hearing, is to consider what we might be "mobile" in relation to: Clouds, Pressure, Jet Streams . . .

> *Will it be possible to consider sonic arts whose sounds remain fixed in space, where those who perceive it do the moving? Does the Aerocene contain the ability to reform our relationship to the already-fraught causal chain of perception? After all, the cliff or the cloud sensing a transient human presence is a geologically analogous accounting for, in the same manner in which a human might perceive a sound event – it may be that we are the ones being perceived in the first place.*
>
> *With our speeds, variations, and repetitions, we might think about this as becoming-sound to the Earth. We might think of our own paths and trajectories as brief sonic events on a geologic time-scale.*

Anthropocene, Aerocene, and aero-acoustic arts all imply a re-negotiation of the position of the human with regard to monumental scales of space–time. Might the Aerocene's de-centering and "opening up" of the human allow for sonic arts that take advantage of slower and dispersed modes of perception and communication?[4] Might it be possible to think about sonic arts whose spatial and temporal parts are constituted of circular streams instead of trajectory (causal) mechanics?

INVITATION III: EMERGENT PERFORMANCE/EMERGENT MAPPING

> *When as humans we understand our floating perception, we may find our localities linked though "holarchic" network* relationships.*[5] In this confluence of events, agents, and feedback, an emergent form is the map that manifests. While perception of the world may be our most immediate sensual relationship, we are responsible for re-thinking any sense in which we consider it toward the top of any hierarchical existential structures. Instead, re-framing:*

What are the emergent forms of perception? What are ways to consider distributed perception? Aerosolar structures will be present in every aspect of these distributed mapping networks – emergent sound events will be able to be reflected and re-distributed through cyclical paths and streams corresponding to emergent weather events:

Do our aero-acoustic arts begin to resemble streams of weather events rather than fragmented performance structures?

How might we think about aero-acoustics as a mapping in and of itself? As a collaboration (or co-creation) with geophysical conditions? What can be learned by performing with?

INVITATION IV: . . . AND WHAT ARE THE EARS?

The aerosolar sculptures already represent the distributed airborne nature of perception. These membranous surfaces and structures – with a few additions – could be re-imagined as Floating Ears with perceptive, otoacoustic, and generative capacities. As both physical and acoustic transducers, they are able to hear and feel varieties of pressures and forces – their shapes and sizes may also mean that certain sized membranes of specific materials may be more or less sensitive to widely different ranges of Aerocene and aero-acoustic activities. Aerosolar structures become implicated in a vast topology of emergent forms (weather,

sounds, performances) and would be able to sense and transmit versions of each.

Like our ears, these aerosolar sculptures simultaneously are able to generate as a part of hearing; hearing and projecting occupy the same event space as aero-acoustic emissions. Using directional- and reflection-based sonic technology such as parabolic or ultrasonic speakers, aerosolar structures will be able to speak to their vicinities, address clouds, and whisper into the jet streams. As a reflective membrane, aerosolar sculptures enact the physical act of hearing simply by travelling through the Aerocene. Through simple digital signal processing (DSP) technologies, we would be able to turn aerosolar sculptures into augmented models of human ears, but what would be the point? Instead, we have the opportunity to make new ones, which might work simultaneously in the communicative, performative, and perceptive modes, translating and performing new territories. Aerosolar sculptures reading the troughs and peaks of Aerocene space as a needle reads the grooves on a record.

INVITATION V: . . . AND WHAT ARE THESE SOUNDS?

New streams of data mean a new approach to sound; if we re-frame the space of human hearing to include that of projection, then the act of projection must necessarily involve its reception. If this feedback loop remains in the realm of the human, then this is not a new or particularly unique idea – it never leaves the ground, so to speak.

> *Instead, we might re-frame this process in the context of Rosenboom's propositions for extraterrestrial communication: what are the data implicit in the sounds we make? How might we begin to think about sonic arts as communication with alternate intelligences? Is there an aspect of the sonic arts in the Aerocene in which these growing forms of projection and reception may be imbued or embedded with information or communicative impulses?*
>
> > *Maryanne Amacher's collaboration with architectural and acoustic intelligences.*
> > *David Rosenboom's proposition for collaboration with extraterrestrial intelligences.*
> > *An aero-acoustic collaboration with geologic intelligences.*
>
> *In what ways can we create (spatially) vertical sonic relationships? How might we encourage collaboration between diverse ecologies?*
>
> > *Anja Kanngieser's answer:*
> >
> > > *[S]ound offers a way of building the different ecologies necessary for political attenuations to forms of life and matter, which are not of the human. It calls for a different realization of time, whether a deep time or atemporality, in which, as [Ursula K.] Le Guin (2014) put it, the 'poetry of the rocks' resounds.*[6]

The beauty of Kanngieser's proposition rests in her insistence on the navigation and translation of diverse ecologies, and further, the need to consider the temporal realm as a unique—or perhaps an intersection of an infinite number of—network(s).

SUMMARY: AEROCENE POSITIONALITY

So the question remains, how might sound and the sonic arts traverse extra/non-human spaces? The Aerocene implies a re-framing, not only of the spaces of human action, but also the expansion of intelligent systems and

collaborations with new spaces. One ought then to understand the space of the Aerocene as places for collaboration, understanding, and communication. How might sound be used to translate non-human intelligences and systems into understandable forms, and how might it be further enhanced to expand our sense of what is recognizable as knowledge? Re-conceptualizing sonic arts as aero-acoustic arts will allow for the sensual topologies of human perception to be in communication with Le Guin's poetry of diverse ecologies—for performance models to encounter ideas of emergence and distribution. Understanding the full-ness of air, it becomes far less daunting to imagine the aero-acoustic arts as a constant and continuous collaboration with distributed membranes, pressure systems, and emergent behavior systems – the space made possible by the Aerocene and the aerosolar position.

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[1] Maryanne Amacher, *Sound Characters (making the third ear).* New York: Tzadik, 1999.

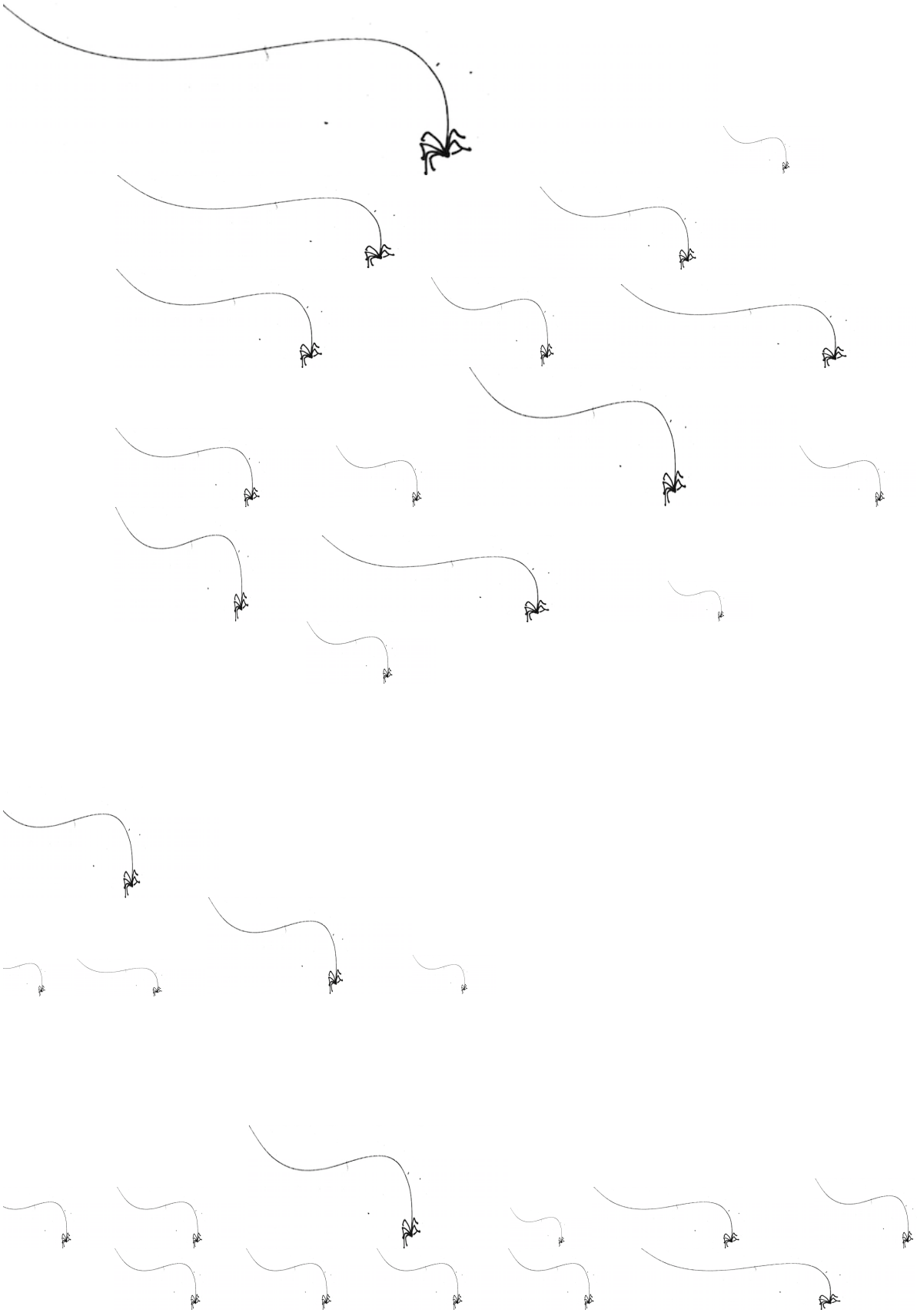
[2] Gascia Ouzounian, "Embodied Sound: Aural architectures and the body," *Contemporary Music Review*, vol. 25, nos. 1/2 (2006): pp. 69–79, here p. 78.

[3] Bronislaw Szerszynski, "Up," *The Aerocene Newspaper*, 2016 [online](http://www.aerocene.com/newspaper/) (accessed May 31, 2016), p. 15.

[4] Ibid.

[5] David Rosenboom, *Collapsing Distinctions: Interacting within fields of intelligence on interstellar scales and parallel musical models*. David Rosenboom Publishing, 2003, p. 18.

[6] Anja Kanngieser, "Geopolitics and the Anthropocene: Five propositions for sound," *GeoHumanities*, vol. 1, no. 1 (2015): pp. 80–5, here p. 83.



Planetary mobilities: movement, memory and emergence in the body of the Earth

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ABSTRACT In this paper I present a unified framework for understanding abiotic, biotic and technological mobilities as achievements of a far-from-equilibrium planet self-organising over geological time, and generating informationally rich forms of matter and motion. I discuss how flows of energy through the Earth support the emergence of different kinds of movement in spatially distinct 'mobility regions' and scale-related 'mobility situations'. I also discuss how technological mobilities exhibit forms of 'gratuity', a relative uncoupling of different aspects of motion, which have arisen repeatedly in the Earth's past, and may presage the emergence of radically new forms of planetary mobility.

KEYWORDS: mobilities, complexity, self-organisation, Earth systems, physics, thermodynamics, mobility regions, mobility situations, gratuity

Contents

Introduction

The now well-established interdisciplinary field of mobilities – the study of large-scale movements of people, objects and information across the world – has its roots in the social sciences, yet often draws some of its vocabulary from the physical sciences. For example, authors have described mobilities in terms of flow (Law, 2006; Urry, 2003, pp. 59–74), turbulence (Cresswell and Martin, 2012), friction (Cresswell, 2013; Tsing, 2005) and viscosity (Doherty, 2015). However, these concepts have largely been deployed in a metaphorical way, and there has been little sustained engagement in the mobilities field with the physical sciences. In this paper, I will make a contribution to correcting this lacuna, showing how insights from a number of scientific fields including fluid dynamics, thermodynamics, animal locomotion, geomorphology and astronomy, can be combined to shed light on the movement of people and things.

In particular, building on the work of Peter K. Haff (2010; 2012), I will set out an approach to mobilities that makes no *a priori* distinctions between the abiotic (non-living, physico-chemical processes), the biotic (organic life) and the technological (artefacts, tools and machines), and that treats all mobilities in the Earth as emergent phenomena generated by a planet organising itself under the constraints of physical laws and imperatives. Thus, by talking about *planetary* mobilities I am not simply referring to long-distance mobilities, or mobilities that accumulate into a dense set of connections over the surface of the Earth; treating the Earth as a loosely bounded dynamic assemblage that extends through the atmosphere into near space, I am suggesting that we should look at *all* mobilities occurring in the Earth as achievements of a far-from-equilibrium planet, under the thermodynamic imperative to dissipate energy gradients, self-organising over deep, geological time and thereby creating its own unique history and set of powers. In order to do so we will have to talk not just about *motion* – of both fluids and solids – but also *information*, here defined as rare and highly correlated states of matter that are difficult to achieve (Hidalgo, 2015), and various forms of 'Earth memory', in which information is not just created but also preserved and made available in the future to enable the planet to do new things.

Since for a large part of the paper I will be suspending distinctions between the abiotic, the biotic and the technological with a view to highlighting wider patterns that cut across them, I will use some broad, cross-cutting categories of mobility. An important distinction made by Haff (2010) is that between *advective movement* (mass parallel motion) and *diffusion-like* movement (multi-directional movement with frequent changes of direction), but other distinctions that I will use will include those between *mixing* (destroying density gradients) and *sorting* (creating density gradients), *singular* versus *repeated* motions (the latter including both the 'shuttling' of specific entities and 'cycles' involving classes of entity or materials) and *random* and *directed* motion. In practice, none of these mobilities is likely to happen in isolation. On the contrary, a further characteristic of mobilities in a dense, relatively enclosed and self-organising part of the universe like the Earth is that mobilities spatio-temporally 'tune' or 'clash' with each other (Haff, 2010, p. 1164).

Three concepts will emerge as particularly important in my analysis of planetary mobility. I will discuss various 'mobility regions' – spatially distinct zones with different material and energetic characteristics – and 'mobility situations' – particular balancings of forces at different scales and speeds. In all of these, physical properties combine to

make possible particular kinds and powers of mobility. But I will also suggest that some kinds of mobility exhibit forms of 'gratuity', a relative uncoupling of different dimensions of mobility such as those of power and direction, carrier and carried or matter and information. While gratuity is more clearly manifest in anthropogenic, technologically mediated forms of mobility, it also points to a wider dynamic in planetary mobilities and can help guide speculation about possible planetary futures. But in the next section I will first start to explore how we can understand the complex, interlinked set of mobilities in the Earth as a planetary phenomenon – as radically conditioned by the long, emergent process of the self-organisation of matter over the 4.5 billion-year lifetime of the Earth.

Planetary evolution

The primary source of all free energy in the universe is the original gravitational potential of matter when it appeared, evenly spread, in the very early universe due to the decay of the earlier, unstable 'false vacuum' (Lineweaver and Egan, 2008). The second law of thermodynamics, when reinterpreted as a principle of maximum entropy production, stipulates that physical systems will tend to degrade gradients, and to develop systems to degrade them (and thus increase entropy, or disorder) more quickly (Dewar et al., 2014). However, as systems evolve there is typically a dialectic between mixing (the destruction of difference and gradients) and sorting (and thus the creation of new gradients). In the case of the early universe, it was the gravitational clumping of matter that allowed the emergence of non-equilibrium, producing 'dissipative structures' such as galaxies, solar systems and eventually planets (Lineweaver and Egan, 2008). As part of the onward rush towards overall disorder and entropy, these dissipative structures (Prigogine and Stengers, 1984) create local order (highly correlated states) and new gradients, thus greater complexity and informational order, including new kinds of motion. The result at the scale of solar systems and planets is patterns that are specific and irreversible; planets are not just mixtures of different chemicals and states of matter, but have unique, divergent and emergent histories (DeLanda, 1992). The Earth thus has to be seen as a body which emerged, evolved and continues to evolve in an ongoing dialectic between the intensive (differences and gradients) and the extensive (form and structure).

Even before the formation of the Earth, the accretion of the solar system from the solar nebula was already a great sorting which occurred through complex forms of mobility. A key 'saddle point' dividing the mobility regions of any solar system is the 'frost line', beyond which solar heat is weak enough for volatiles such as water, carbon monoxide and methane to freeze. This line is positioned differently for different volatiles and around different stars, but in our own solar system is just outside the asteroid belt (Prockter, 2005). The eventual effect of this was to produce a complex but ordered planetary system with gas and ice giants outside the frost line and small rocky planets within. Inside the frost line, volatiles evaporate and smaller 'terrestrial' planets accrete from metals and heavier atoms; outside the frost line, giant planets form due to the greater number of solid particles and their ability to retain greater amounts of light gases (ibid.).

From a planetary mobilities perspective this is also a sorting of *powers* of mobility: the creation of bodies which have different powers to move things around within themselves. Planets, by definition, come to dominate their area of the solar system – and sometimes move to new stable orbits so they can do so (Soter, 2006).

Isolated in the vacuum, planetary bodies follow the ellipses, parabolas and hyperbolas of gravitational motion, guided by the absolute memory of reversible Newtonian mechanics. Within themselves, however, their gravitational collapse into planetary bodies will produce energy gradients and far-from equilibrium conditions which favour the emergence of local order. Planets are bodies where the combination of fluid motion and solid durability creates information-rich pockets, where correlated states and motions can arise, endure and become more elaborate (Hidalgo, 2015). Astronomers talk about the 'Goldilocks' or 'habitable' zone around stars which enjoys the temperatures enabling the emergence of water-based life; but such zones are just one of the many self-organising 'mobility regions' in which planets can acquire different powers of internal motion. For planets and other astral bodies to 'learn' in this way – to have a unique and irreversible history of emergence – they need new ways of recording, recalling, learning and forgetting past mobilities. As Prigogine and Stengers put it, classical dynamic systems such as those governing planetary motion in what the ancients called the 'superlunary' world of the heavens already know everything they need to know in order to move along their orbits, and can never forget it (Prigogine and Stengers, 1984, pp. 305–6). But in the sublunary, far-from-equilibrium world of planetary becoming, what are needed for new mobility powers to develop are interacting systems of *non*-Newtonian memory: fluid memory (residing in the motion of flows, eddies or vortices), solid memory (in the stratigraphy, geodiversity and surface morphology of the solid earth, and in complex objects) and code memory (in DNA, culture with its arbitrary symbols or computational machines).

If information is important for planetary mobilities, no less so is energy. Energy as defined by modern science cannot be created or destroyed, but it can be higher or lower in quality, as defined by its availability to do 'work' – in effect, to move macroscopic objects or create macroscopic gradients. However, the amount of work that can actually be done by the energy in any system (for example a pressurised container) depends on the difference between the energetic levels of that system and those of its environment. This difference is termed 'exergy', the amount of energy that is available to do work in relation to a suitable reference state, and this decreases as entropy increases. In the solar system, the primary reservoirs of exergy are the nuclear energy from fusible atoms in the sun and fissionable atoms in planetary bodies, the gravitational and kinetic energy of the solar system, and the residual thermal energy remaining from its formation (Hermann, 2006, p. 1689). From these primary reservoirs, energy cascades into secondary reservoirs, a cascade which within planets is conditioned by their particular history of self-organisation.

The outer planets – the gas giants Jupiter, Saturn and ice giants Uranus and Neptune – are so far from the sun that they receive little energy from it; instead, the motion of their atmospheres is driven mainly by the residual internal heat from compression and friction. Despite their coldness, the availability of different chemical elements with different melting points allows the outer planets and their moons to have rocks, atmospheres, seas and hydrological cycles, just based on different chemistry. Their residual inner heat is also sufficient to sustain vertical temperature gradients that ensure that even the extremely cold atmosphere of Neptune, which only receives $1/900^{th}$ of the solar energy per unit area that the Earth does, nevertheless has the most violent weather in the solar system (Suomi et al., 1991). The huge gravity wells of the outer planets also allow them to form highly complex satellite systems, with rings,

shepherd moons that maintain ring boundaries and co-orbital moons that swap orbits (Spitale et al., 2006). As we explore the outer planets we are likely to find more and more unique mobility patterns in and around them.

Planets such as the Earth that formed and move within the frost line are very different. The higher temperatures closer to the sun do not mean more liquids and gases; instead, the greater power of the solar flux and solar wind strips volatiles away, making the inner planets smaller and more predominantly solid. The solar flux also dominates the energetics of their outer layers. The surface of the Earth, for example, receives nearly 2000 times more energy from the sun than it does from the planet's interior (Davies and Davies, 2010). The inner planets are thus subject to a constant excess of electro-magnetic energy, and one which is unevenly spread across their spherical surfaces. Energy leaving the Earth system has to be equal to that arriving in it for its average temperature to remain relatively constant. But the majority of incoming solar energy works its way through the Earth system before it is converted to heat and radiated back out. Apart from the tidal movements caused by gravity, the major fluid motion on the Earth – of the winds, the ocean and the wider water cycle – is driven by this solar energy, as radiative gradients produce temperature gradients, themselves producing pressure and density gradients, and thus motion (Kleidon, 2010). In the next section, we will look at this fluid mobility.

Fluid motion

In fluids, whether liquid or gaseous, atoms and molecules are not locked into a rigid structure, so movement is *prima facie* easy; fluid flow is thus unsurprisingly a massive part of the Earth's mobility. Haff (2010) suggests that we measure the movement of mass in the Earth using a dynamic metric of 'mass action', calculated as the product of mass delivered, distance travelled between changes of direction and average speed, and measured in $kg \cdot m^2/s$.[1] If we exclude the direct flow of the Earth's core and mantle, the largest movements in the Earth as measured by mass action are advective flows within the atmosphere and ocean. Hermann (2006) estimates that of the 162,000 TW cosmic radiation reaching the Earth, 870 TW – 10 times the energy that enters the biosphere – is transferred to atmospheric kinetic energy, including wind, waves and the water cycle. The two largest motions of the atmosphere are the overturning 'cells' that make up the troposphere and the high, Westerly jet streams that flow along their boundaries. Motion in the oceans is comparable in scale. The five great oceanic gyres, caused by a combination of prevailing surface winds and the Coriolis effect, have a combined mass action of $4{\cdot}8 \times 10^{24}$, kg·m2/s. The thermohaline circulation or 'ocean conveyor belt' follows a path that wanders around the world's oceans at various depths, caused by combination of wind-driven surface currents and density gradients in the water dynamically maintained by interaction with the sun and the land. It has a total mass action estimated as 3.0×10^{24} kg·m2/s (Haff, 2010, p. 1161).

As well as the reservoirs of air and water having their own internal mobilities, cutting across these is the water cycle, a closed cycle in which flow between ocean and land is crucial. Every year about 577,000 km^3 of water (0.04% of the Earth's water) evaporates into the air from the Earth's surface - 1,580,000,000,000 tonnes per day – nearly 90% of which comes from the ocean. Its average residence time in the air is 8–9 days, which means that at any one time the atmosphere is estimated to contain 12,900 km^3 or 0.001% of the world's water; if it all fell at once it would form a 25mm-thick layer

over the surface. 20% of precipitation falls on land (albeit very unevenly); the Earth's rivers, which at any time only hold 0.0002% (2,100 km^3) of global water, cumulatively carry 40% of land precipitation to the oceans, by renewing their water every 16 days (Shiklomanov, 1993). They thus constitute a fifth great fluid motion system, just four orders of magnitude lower in mass action than the four mentioned above. The largest technological fluid flow system, long-distance pipelines, is smaller than all these – much smaller in mass moved per second, though because of the distances travelled, in mass action it is beginning to rival rivers and precipitation taken as separate mobilities (Haff, 2010, p. 1161).

Fluid motion is not just quantitatively significant, but provides the main mechanisms for creating gradients and sources of free energy within the Earth (Kleidon, 2010). However, fluids lose macroscopic conformational information, the information stored in the arrangement of parts: even when their mass moves advectively as whole, fluids deform as they move; if gaseous, they also compress and expand. What moves to a new location is mass and energy, including any variation in chemical composition and heat, but little else. Neither can fluids by themselves remember where to go; inertia tends to be quickly dissipated by viscosity or turbulence, and the motion of each individual molecule is determined by the actual internal gradients at that time and place. When applied energy gradients enable fluids to form far-from equilibrium vortices such as Bénard cells in heated liquids, or cyclones in the tropical atmosphere, complex choreographies of motion can arise at macroscopic scales of centimetres and kilometres (Prigogine and Stengers, 1984, p. 144), extending fluid memory to timescales of days; even small vortices can help fluid motion to remember initial conditions (Zhou and Antonia, 1995). However, fluid motion is intrinsically more forgetful, and on its own shows limited capacities for supporting the emergence of new forms of order, and thus new and complex kinds of mobility.

Solid motion

The movement of solids may be more interesting than that of fluids, but it is also more difficult. The very feature of solids that enables them to carry conformational information means that all atoms have to move together, requiring huge forces. Solids are also on the whole denser, so heavier per unit volume; furthermore, on the terrestrial surface, the Earth's gravity produces friction between object and ground, which tends to keep solids in place. So it should not be surprising that solid movement is much smaller than fluid motion in the Earth. Even the largest systems of solid movement in the Earth have mass action that is 4 or 5 orders of magnitude smaller than the largest involving fluids. For solid motion, the largest mass action occurs in cases where massive solid entities are moving very slowly due to an applied force, such as continental drift, sea-floor spreading and Antarctic glacial flow (Haff, 2010, p. 1161). After that, solids move more easily when they are 'discretised' – broken up into smaller pieces. When broken up into small enough particles, solids can hitch a ride in the advective flow of fluids, with the mass action of river sediment and aeolian dust estimated at $5{\cdot}0 \times 10^{17}$ and $2{\cdot}0 \times 10^{17}$ kg·m2/s respectively (ibid.). They can also use the enveloping fluid to reduce friction, for example in submarine landslides. Under certain conditions discretised solids can themselves flow and move in fluid-like ways – in avalanches of sand and rock, for example.

In the evolution of the Earth there have been a number of crucial 'bifurcations', irreversible revolutions which shaped the capacities of its internal parts to move in different ways (Lenton and Watson, 2011). These include the emergence of life, and later that of animals. On an Earth without life, the remainder of the incident solar energy that is not converted into fluid motion of air and water would be either scattered back into space as electro-magnetic radiation, or converted to heat. The biosphere now captures a small but significant amount of that energy. Of the 86,000 TW of solar exergy that reaches the Earth's surface, 10-20,000 TW falls on plants and algae. Some of this simply powers evaporation from plant surfaces, feeding back into the energetics of the climate system. But 0.5-1% of it is captured by photosynthesis, resulting in an energy flow into the biosphere of about 90 TW (Hermann, 2006). If we simply had a biosphere consisting of photosynthesising autotrophs, this cascade of solar energy would no longer be converted into significant motion, but largely used for organic maintenance, growth and reproduction. But the emergence of animals changed that.

Haff (2012) argues that animals (and their later offshoot technology) overcame the challenges to large-scale solids transport in the Earth through three main innovations – internal power, rotary motion and infrastructure. The first innovation involved not relying on ambient energy alone but having an onboard store of chemical energy that can power motion. The abiotic motion of fluids or suspended particles relies on ambient gradients of gravity or pressure; single-celled organisms gain their energy from sunlight or 'osmotrophically', by absorbing chemicals through their membrane, so are also in a sense dependent on ambient energy sources. But about 2 bya (billion years ago) some single-celled organisms learned to engulf particles or other organisms, processing them internally for their nutrients (Lenton and Watson, 2011). Around 0.6 bya animals took this further; through multicellularity and cell-differentiation they became able to grow multiple tissues, to develop a tube from mouth to anus that enables them to process and absorb ingested food, and to store as sugars and fats any energy that was not immediately needed (Butterfield, 2011).

This ability to absorb and store larger quantities of nutrients both enabled and required new forms of mobility. For subaerial, terrestrial motion, larger solid moving entities have to overcome the problem of friction – the second major challenge to solids transport that Haff (2012) identifies. Haff points out that the innovation of rotational motion (limb motion or undulation in animals, wheels in machines) turned friction from a problem to an asset. Studies of animal locomotion show that all animals have evolved to move in a way that maximises the proportion of total expended energy that is actually used to propel the animal's body forward (Bejan and Marden, 2006), within the constraints of evolution, lifestyle and environment.

In quantitative terms as measured in units of 'mass action', the motion of these new animals was and remains tiny compared with that of the fluid compartments of the Earth or their suspended solid particles. But in a qualitative sense it was hugely significant, representing a new stage in the arising of 'form' in the Earth (Szerszynski, 2016). Animal mobilities represented a new 'needful freedom' to add to that of the metabolic relationship between the organism and its environment (Jonas, 2001): animals moved to eat – but also ate to move. Their presence also brought about a new relation in the Earth – that between predator and prey. This opened up a whole new 'phase space' for life in the Earth with an open-ended, evolving set of gradients on which different life forms became arranged – speed, size, hardness, alertness,

digestibility and so on. This in turn produced a huge acceleration in the evolutionary 'arms race' (Lenton and Watson, 2011, p. 286), and propelled the Earth towards its current dynamic, self-regulating biosphere with vastly greater amounts of standing biomass and internal recycling of elements (Butterfield, 2011) .

This energetically open but materially closed 'Gaia' of the Phanerozoic aeon (the last 0.5 billion years) has made the Earth even more effective in degrading exergy. This acceleration of entropy production has involved the emergence of new, terrestrial levels in the energetic cascade from the solar system's primary energy reservoirs mentioned above. The fraction of incident solar exergy that is directed into the biosphere is first captured by photosynthesising plants and algae; however, these 'autotrophs' or 'primary producers' form only the 'lowest' trophic level of the biosphere, on which feed primary consumers (herbivores), then secondary consumers (small carnivores) and sometimes other levels before we arrive at peak predators. In each trophic level the majority of the energy coming in is used to maintain the metabolism of the organisms and only the remainder for growth and reproduction. This, combined with the limited efficiency of assimilation, means that each level can only capture an average of 10% of the energy of the previous level, so that as one moves up trophic levels populations and total mass and available energy decreases (Pauly and Christensen, 1995). It is thus not surprising that the systems of non-human living solids transport with largest mass action according to Haff's calculations are migrating animals on relatively low trophic levels and in low-resistance environments – whales, fish, birds and caribou – each of whose cumulative mass and distance travelled allows them to rival in mass action all other examples of solids movement not propelled by flows of air and water (Haff, 2010, p. 1161).

Yet even the latter are now rivalled in mass action by the main technological mobilities systems – maritime shipping, rail, trucks and automobiles (Haff, 2010, p. 1161). In sheer energetic terms this has clearly only been possible by the accelerating mining and combustion of fossil-fuel energy reserves. As well as capturing an estimated 24% of the net primary production of the terrestrial biosphere (Haberl et al., 2007), or about 16 TW of energy (Hermann, 2006, p.1692), humans also now tap into geological reserves of energy at a massive and growing rate. Humans currently generate 5.1 TW from burning oil, 3.6 TW from coal and 3.2 TW from gas, from estimated geological reserves totalling 430 ZJ (Hermann, 2006). In terms of the payload being carried, human-transported mass has historically been mainly biomass: fuel and food. However, in the developed world this has recently being overtaken by the flow of minerals and metals, as advanced (and emergent) economies move towards building and maintaining a growing infrastructure of buildings, roads and durable goods; it is estimated that the standing stocks of materials in such structures amounts to several hundred tonnes per person in industrial societies (Schaffartzik et al., 2014). Global mining and quarrying are estimated to move more than 57 billion tons per year – more mass than is moved either by glaciers or water erosion (Bridge, 2009).

In human-induced mobilities of biomass and minerals, a crucial role is played by 'motilisation' – the transformation of non-motile local geological, ecological or economic resources into materials capable of advection in global currents of flow. This partly involves the discretization of biological or geological entities in order to make them easier to move. As Lewis Mumford put it, in the modern period 'the methods and ideals of mining became the chief pattern for industrial effort throughout the Western world.

Mine : blast : dump : crush : extract : exhaust' (Mumford, 1934, p. 74). But at the same time it involves converting things in a qualitative sense into abstract and exchangeable 'material'. This is what Andrew Feenberg calls 'primary instrumentalisation': the decontextualisation of 'raw materials' out of their naturalistic context (rocks in the ground, or trees in a forest) and their reduction to primary qualities such as chemical composition, brittleness, homogeneity and strength (Feenberg, 1999, pp. 203–5). Motilisation of raw materials and their incorporation into global advective flows can also of course involve forms of cultural and political violence (Tavares, 2013).

Mobility regions

We saw in the section on planetary evolution that the solar system can be divided into different regions of space where a specific set of physical characteristics gives rise to particular forms and patterns of mobility. The body of the Earth, too, can be divided into different mobility regions. In this section I will focus on the kinetics and energetics of mobile solid entities (whether abiotic, biotic or artefactual) in different '*mobility regions*' – some characterised by a single medium such as air, water or loose earth, and some at the boundary between different media.

Firstly, then, some solids move *within a single medium*. As we have seen, some of the largest solid flow in the Earth is the passive transport of suspended particles such as river sediment and aeolian dust. But many self-powered objects also move in the midst of air or water – birds and aeroplanes, fish and submarines. Because of the low density of air, flying requires lift as well as thrust and so is more costly per unit time than either swimming or terrestrial motion (Goldspink, 1977a 164-5); however the low viscosity of air allows faster speeds so flying is more energetically efficient per unit distance. Animals make up the vast majority of marine biomass (Butterfield, 2007, p. 48); marine animals can move with great efficiency at low speeds, especially when using 'lift' forces to produce forward motion. However, drag in water increases with the square of speed, so, unlike motion in air, motion in water has optimum speeds in terms of energetic cost. Drag is also increased further by the presence of buoyancy organs (Alexander, 2003, p. 310), and oxygen levels in water are low, so aquatic animals only engage in fast swimming in bursts (Goldspink, 1977a 165). Some animals engage in 'fossorial' motion under the ground, but energy costs with this form of movement tend to be high (Trueman and Jones, 1977).

Secondly**,** however, some solid mobility occurs on the *boundary between media* – between gaseous and solid (on or near the subaerial land surface), liquid and solid (in the benthic layer of water bodies), or gaseous and liquid (on the subaerial surface of a body of water). Abiotic motion in these boundary zones includes gravitational motion (landslides and mudslides) and fluid-powered motion, such as the reptation (creeping) and saltation (jumping) of subaerial soil and sand, or wind-blown debris floating on water. Such powers of motion are profoundly shaped by the velocity gradient across the 'boundary layer' close to the surface, within which the velocity of the fluid as one approaches the surface starts to approach that of the surface (Vogel, 1994, pp. 174–203). By contrast, self-powered entities moving on the boundary between media, whether biotic or technological, are subject to very different constraints, as they try to move more efficiently by exploiting the different properties of the respective media. Swimming at the fluid–fluid water–air boundary is less efficient than subsurface swimming, since surface swimmers produce wakes which dissipate energy and tend to

use the less-efficient terrestrial styles of motion (Goldspink, 1977a 158). Massive containerships are better able to exploit the energetic properties of surface swimming, but the economics of freight delivery forces them to go faster than would be optimal; above 14 knots, energy use rises exponentially, since ships are constantly climbing their bow waves (Vogel, 2013, p. 277). However, the Earth-air boundary is probably the most significant for self-propelled solid motion on the Earth.

On the subaerial terrestrial surface, animals use their limbs or sinuous motion to take advantage of the combination of high friction between their body and the 'ground' (broadly conceived), and the low viscosity and high oxygen content of the air. Locomotion techniques can be cursorial (walking, running), saltational (jumping, hopping) or arborial (climbing, swinging). Terrestrial limb motion itself uses low energy thanks to the low mass of limbs and the use of elastic tension to store unused energy in each swing and reuse it in the next. However, energy use per unit time in terrestrial motion is higher than that of swimming (Goldspink, 1977a, p. 164) , though larger terrestrial animals are more energy efficient (Goldspink, 1977b, p. 78).

Technological mobility on the land surface was not a hugely significant phenomenon until the advent of motorisation and sophisticated transport infrastructures. Wheeled transport initially emerged in order to make better use of animal (including human) energy. Two-wheeled carts and chariots were developed in Asia for use in agriculture, warfare and ceremony (Mazoyer and Roudart, 2006, p. 445), and were the basis for the later development of the cumbersome European heavy 'wagon', used for freight and sometimes passengers. Lighter 'carriages' for passengers emerged mainly in 15th century Hungary, soon spreading and diversifying across Western Europe and then North America; their use, like that of the earlier chariot was largely elite and driven by processes of social distinction (Piggott, 1992). Mechanised land vehicles such as the train, automobile and truck evolved, morphologically speaking, from the carriage, but this continuity belies the way that the motorisation of vehicles triggered a 'major transition' in the evolution of terrestrial motion.

Firstly, the shift of energy source from animal feed to massive stocks of energy-dense fossil fuels meant that calculations of energetic efficiency (whether explicit or tacit) became dominated by the amount of energy expended in obtaining and refining the fuel, rather than the amount that the fuel contained, encouraging far greater energy use (Hall et al., 2014). Secondly, the main driver in land transport, measured by mass and distance, became now not agricultural labour or social status but the needs of a commercial society constituted of dispersed land-based settlements, with populations undergoing a growing division of labour and increasingly dependent on distant natural resources (Zalasiewicz et al., 2014, p. 44). Thirdly, the spread of motorised land vehicles necessitated the overcoming of 'form-resistance' due to irregularities and obstacles on the land surface (Haff, 2010, p. 1161), since existing roads were only suitable for animal motion or large, slow wheels; the speed and reliability offered by the new vehicles only became possible with the building of extensive infrastructure, with railroads in the 19th century and then metaled roads and highways in the 20th (Grübler, 1990).

Mobility situations

Even where different entities are moving within the same spatially defined mobility region, they can nevertheless enjoy very different powers of motion, due to their experiencing a different balance between the various physical forces that act on matter.

A series of 'dimensionless numbers' can be used to characterise the balance of different forces in particular 'mobility situations' – particular couplings of size, mobility and environment. The entire mobility 'phase space' within a given mobility region can be seen as constituted by a range of mobility situations (or 'flow regimes'), some functioning as self-reinforcing basins of attraction, others forming unstable 'manifolds' between them. For example, Bagnold numbers (viscosity versus grain inertia in granular flow) characterise different mobility situations in mudslides, avalanches, and flows of sand, concrete or grain. Froude numbers, which measure the relative predominance of gravity and inertia, can be used to understand the sorting of particles in air and water, gait transition in animals, and the different mobility situations of ships and other surface swimmers going at different speeds in relation to their size. The form-resistance in land-based mobility discussed above is also a function of relative size of moving entity and obstacle. But perhaps the most crucial dimensionless number in planetary mobilities is the Reynolds number, which concerns the balance between viscosity and inertia.

The Reynolds number is crucial for motion within a fluid medium, whether passive (with the flow) or active (against it). Crucially, the Reynolds number, like many other dimensionless numbers, applies to a whole mobility situation rather to a particular mobile object or medium (McMahon and Bonner, 1983, p. 96); thus, a *low* Reynolds number (what is called Stokes flow) might be produced by one or more of a number of factors: small scale (e.g. swimming bacteria or sperm), highly viscous matter (e.g. lava flow) or slow speed. With Reynolds numbers greatly below 1, viscosity and friction is powerful and inertia is negligible. In this mobility situation it is not possible to swim like a fish or whale, thrust then glide; any moving entity has to keep its power on or it will stop. Fluid flow is slow, linear, and uncannily reversible; mixing is almost impossible (Vogel, 1994, pp.331–61). This physics makes locomotion very difficult: the organism has to break with time-reversible symmetry – so small single-celled organisms had to evolve non-reversible movements, such as whip-like flagella turned on rotary axles (Purcell, 1977).

However, even in regions that smaller entities would find viscous, if entities are large enough, or move fast enough relative to the medium, then they will inhabit a high-Reynolds, inviscid flow regime in which inertia dominates and viscosity becomes irrelevant. Birds and fish live at high Reynolds numbers, and planes higher still (McMahon and Bonner, 1983, p. 95). Here moving objects can use the weight of their body to continue forward motion, but outside the laminar boundary layer of fluid right next to the moving object, inertia produces eddies undamped by viscosity, producing further eddies that cascade down to smaller scales where they are degraded away by friction. In this flow regime (for example in water at medium speeds, or in air at high speeds) morphology becomes extremely important because of drag and lift – hence the convergence of form between planes, submarines and dolphins.

Amongst other things, the Reynolds number affects the possibility of passive, suspended transport. Because they are gaseous, atmospheres have densities and viscosities that are much more variable than those of liquids. The air of the Earth is intermediate in density and viscosity between the thick atmospheres of Venus and Titan (the largest moon of Saturn) and the thin atmosphere of Mars; amongst other things, this affects what these worlds can do to mobilise ground particles. On Earth, soil particles, depending on their size, inhabit different mobility situations in relation to the fluid flow of the atmosphere. Those below 70μm in diameter or below can be lifted and

suspended in the air – smaller ones for weeks, travelling for thousands of kilometres; those between around 70 and 500 μm can be made to saltate (jump), whereas those above about 500 μm can only reptate (make small hops) or creep along the ground (Kok et al., 2012, p. 2). The relatively low Reynolds numbers on Earth and Mars also means that saltating particles fall fast, 'splash' and dislodge others, easily creating a metastable haze of suspended particles, and can produce complex dune shapes. Venus and Titan by contrast have thick atmospheres and simple unidirectional winds; on these worlds particles of the same size inhabit a different flow regime with lower Reynolds numbers, more like that under water. Dust particles can only be lifted small heights and are less likely to reach higher, faster winds; they also fall slowly, producing no splash (ibid., p. 23).

But as well as being important in defining immediate mobility situations at different scales, the kinetic and energetic differences captured by dimensionless numbers such as Reynolds numbers can also be 'locked in' to patterns of planetary mobility, producing bifurcations that go on to structure the kinds of motion available to the parts of the planet. Perhaps the most significant example of this is the role played by the viscosity of water in the establishment of the Earth's five kingdoms of life (archaea, bacteria, animals, fungi and plants). Because bacteria and archaea live at very small scales, and inhabit a low-Reynolds regime where water is viscous and inertia is irrelevant, movement after resources is energetically costly; these organisms thus continue to follow a strategy of *economy*, staying small, simple and numerous. In the Phanerozoic world, by contrast, macroscopic, multicellular life (plants, fungi and animals), escaped the Stokes viscosity regime through sheer size and this opened up new possible strategies based on more complex bodies. Both plants and fungi follow strategies which focus on being able to alter their shape in response to environmental conditions, and being resilient in the event of losing parts. Animals adopted a different evolutionary strategy again, one that combined a fixed shape with mobility, thus prioritising flexibility of response to different signals in a shifting environment (Yafremava et al., 2013). Once these different strategies established a new phase space for macroevolutionary development, the trade-off relations between them created positive feedback loops that 'funnelled' lineages further into these divergent strategies. A similar analysis of mobility situations using dimensionless numbers could be used to understand the establishment of different lineages of mobile technological objects, which are also subject to their own evolutionary processes of lock-in, but there is no space for this here. Now we must turn to one remaining feature of some forms of mobility in the Earth, ones which seem to challenge symmetrical modes of description and explanation.

Mobility gratuity

Any comprehensive theory of planetary mobility, however committed it is to explanatory symmetry, cannot ignore features of technological mobilities that seem to defy a purely physical explanation and require the introduction of concepts such as 'mind', 'purpose' and 'intelligence'. Haff captures these features very well when he talks of 'transport of complex payloads with persistent memory, displacement of these payloads independent of geophysical fluid flows and topographic slope, and spatially accurate delivery to fixed but arbitrary destinations' (Haff, 2012, p. 155) – and we might also add the delivery of information using arbitrary material or energetic substrates.

One way to account for the presence of these 'complex' mobilities in the Earth would be to try to identify the 'critical steps' necessary for their historical development, such as the prior emergence of intelligent living beings.[2] However, while such an approach is useful, there is a danger that it universalises the specific steps that were *de facto* involved in the development of complex mobilities in the Earth. In order to avoid an Earth-bound 'observer bias' in our consideration of such issues we need to develop a 'speculative planetology' that is more imaginative about the possible paths that could be taken in the self-organisation of matter in planetary evolution (Szerszynski, forthcoming). Two counterintuitive features of such an approach are relevant here: firstly, that attending very closely to the specific trajectory of development undergone by the Earth can help to identify more general patterns and thereby alternative counterfactual possibilities, and secondly, that following Haff's strategy of downplaying rather than accentuating conventional distinctions between 'natural' and artificial entities, and between intentional and unintentional motion, can actually help us better understand what is so distinctive about certain forms of technological mobility.

The overarching concept that I want to use to capture all the remarkable features of technological mobility which Haff identifies is 'mobility gratuity'. I develop this notion with reference to Jacques Monod's analysis of the nature of life. Inspired by Erwin Schrödinger's (1944) prescient insight that the genetic code must take the material form of an 'aperiodic crystal', Monod (1972) suggests that, with the emergence of the genetic code, crystalline structures themselves gained a new freedom in which chemical affinity was uncoupled from physical function – in biosemiotic language, they gained a new 'semiotic freedom' (Hoffmeyer, 1996). Using the example of how inducer molecules regulate the expression of genes by altering the shape of regulatory proteins that bind to the gene, Monod draws attention to 'the independence, chemically speaking, between the function itself and the nature of the chemical signals controlling it'. He suggests that this '*gratuité*' had the effect of 'giving molecular evolution a practically limitless field for exploration and experiment' (Monod, 1972, pp. 78, 79). I will argue that an analogous process is occurring here: in generating complex mobilities that involve 'arbitrary' relations between origin, mobile entity and destination, the Earth succeeds in opening up new kinds of gratuity in the phenomenon of mobility.

Here I will identify three forms of mobility gratuity, all of which can be found in certain kinds of abiotic or biotic motion, but have arguably been most effectively stabilised and combined in the technological domain. The first is the gratuity between the *magnitude and direction of motion*. Generally, in abiotic mobility situations these two are inseparable – indeed, that follows from the way that energy and force are defined in the physical sciences. As discussed above, abiotic objects or bodies of fluid (if they are not releasing chemical energy, or latent heat through state change) move (we would say) 'passively' under the influence of external gradients which provide both locomotive power and direction of motion. Thus pebbles rolling down slopes obey the law of gravity; molecules or larger objects within fluid flows (air, water or magma) are driven by local density gradients. If the force is greater on one side of the molecule or object than the other, thus giving it potential energy, it will move in order to lose that potential energy, thus converting it to motion.

However, some forms of mobility exhibit an uncoupling of (scalar) power and (vector) direction of motion. Intimations of this kind of gratuity are observable in certain classes of abiotic phenomena wherein mobile things create a partial liberation

from local, ambient gradients by producing their own internal gradients through autopoietic self-organisation. For example, the 'debris flow' and 'turbity flow' regimes of submarine landslides help them to transport vast amounts of sediment far away from continental shelves (Leeder, 2011, p. 171), and tropical cyclones organise their own internal gradients and create huge amounts of correlated motion over many days, by extracting thermal energy from ocean evaporation and coupling vertical updraft with horizontal circulation (Marks, 2003). However, such macroscopic metastable formations are shortlived, and their gross motion still determined by the larger-scale gradients around them. It is in biological and technological entities that this form of gratuity is most effectively sustained and exploited.

In the motile animal, power–direction gratuity has been functionally and morphologically stabilised in the differentiation between the animal's internal (generally chemical) power store and its organs of locomotion. Powered motion in single-celled organisms, when combined with sensitivity to environmental stimuli, enabled them to engage not just in random, undirected 'kinesis' but also in directed 'taxis', moving up or down gradients that are only indirectly related to the energy powering their motion, such as those of chemical concentrations (chemotaxis), light (phototaxis) or oxygen (aerotaxis) (Nealson, 2011, pp. 48, 51). More complex, multi-cellular animals, under the pressures of natural selection, developed far more complex behavioural sequences that perform various functions within their lifecycle and the wider ecology (Breed and Moore, 2012, pp. 257–62). In technological mobilities this particular kind of gratuity is even more visible, with separate mechanisms for propulsion and steering (such as accelerator and steering wheel). Indeed, viewed through this framework, the forms of animal and technological mobility that stand out as interesting are those that do *not* so clearly follow this pattern of gratuity between power and direction: limbless animals such as snakes and eels, or forms of transport relying on ambient energy such as ballooning, downhill skiing and surfing.

A second form of gratuity in mobility is that between *carrier and carried*. Haff suggests that the vehicle–payload split so taken for granted in modern transport systems partly derives from the fact that, unlike in fluid transport, solid payloads naturally maintain their shape and therefore separation from the mechanism that is transporting them, but also argues that it constitutes an 'innovation' that has been necessitated by the functional needs of the Earth's technosphere (Haff, 2012, pp. 152–3). However, viewed as a form of mobility gratuity, the distinction between carrier and carried can be seen as a wider recurrent feature of the evolution of planetary mobilities in the Earth. The shaping of the Earth's solid form has depended crucially on the division between fluid advective flows and their solid payload of suspended particles. The ability of rivers and winds to motilise particles, to mix and to sort, to deliver and deposit, and thus to turn the surface of the Earth into the complex generative region that it is, depends on the distinction between carrier and carried. Even in the case of a chemical solution, or water vapour in the air, chemical difference allows us to talk of a difference (if not always a chemically arbitrary relation) between carrier and carried, evidenced by the possibility of the chemical payload precipitating as a 'deposit'. The emergence of self-propelled animal motion constituted a shift of emphasis within solid mobility in the Earth from carrier–carried gratuity to power–direction gratuity; however, there are still countless examples of animals having organic 'passengers', from plant seeds and bacteria to internal symbionts and parasites, even before humans start domesticating

horses and camels. But with the establishment of what we might call the 'kingdom of machines' the relation between carrier and carried is taken to new levels of arbitrariness, epitomised morphologically in sealed, standardised containers such as the Wardian case in the nineteenth century (Pawson, 2008) and the intermodal freight container in the twentieth (Birtchnell et al., 2015; Levinson, 2006). This form of gratuity is as crucial as power–direction gratuity for today's global flows of freight, as it allows the meshing of long-distance advection between continents (by marine shipping and air), advection between cities (by truck and train) and local diffusive flow (by van).

A third form of gratuity manifest in technological mobility is that between *matter* and *information*. As described above, complex objects such as storms, organisms and artefacts contain 'conformational' information in the arrangement of their parts, and when we say that such entities move, we typically mean that this arrangement also moves. With dissipative fluid structures such as hurricanes, conformational information consists partly in correlated *motion*, and it is this metastable arrangement that persists and moves as different molecules pass through it. With solid objects, by contrast, shape is correlated *position*, and with complex objects there can be a highly complex set of correlations between its parts at different spatial scales. However, some technological forms of mobility have opened up a gratuity between the material and conformational poles of this particular dimension of mobility. Such modes of mobility we typically call 'media'. Thus visual representations such as plans, paintings, drawings or models, and latterly photographs and film, or written descriptions or instructions, enable the transfer of at least part of the conformational information of complex entities and assemblages onto other material objects, which can thus travel without the original matter.[3] With aural, electronic and optical forms of transmission, conformational information can move without any baryonic matter[4] moving with it at all, before it might be turned back into spatial arrangement. With the advent of 3D printing we may see a shift away from the transport of complex objects towards streams of raw materials on the one hand and digitised information on the other (Mohr and Khan, 2015).

It is perhaps more difficult but nevertheless possible to identify non-technological manifestations of this form of mobility gratuity. Until the arrival of human technologies, planetary bodies, although they each lie at the bottom of their own gravity well, seem to have been better at exchanging mass (in the form of meteor fragments) than information. The development of living things and their various endosemiotic (inner) and exosemiotic (externally oriented) significatory processes represents a major transition in the capacity for information to move without its accompanying matter (Hoffmeyer, 1996). However, limited forms of intra-planet matter–information gratuity also occur more widely in the case of bottle-necks or pinch-points in the transmission of form, where a small and morphologically simple 'seed' can under the right conditions reconstruct the original object. For example, given the right chemical conditions, a crystalline fragment can reproduce the form of an original crystal, as molecules from the surrounding fluid arrange themselves geometrically in the energetically lowest state (Pimpinelli and Villain, 1998). Far greater 'bandwidth' is available in the reproduction of eukaryotic organisms – plant, animals, and fungi – where the genetic information contained within a seed, egg or spore is sufficient for the recreation of an entire living entity (Margulis, 1998: 70) – and the behavioural inheritance of an individual organism sufficient for the potential recreation of dwellings and physical niches. In all of these cases, the capacity for the conformational information to move is distributed in different

ways between the entity as 'source' and the environment as 'channel' or enabling condition (Oyama et al., 2001b).

We have seen in this section that technologically mediated mobilities often exhibit forms of 'gratuity', and that these can be seen as a manifestation of a wider phenomenon in planetary self-organisation. However, it is also important to clarify that entities that engage in more 'complex', gratuitous forms of mobility are not simply more 'liberated' from their environment, as direction of travel might be said to be liberated from source of energy, payload from vehicle or information from matter. Instead, forms of gratuity often seem to involve a sharing and distributing of powers between the mobile entity and its environment, in a way that echoes the notions of 'extended inheritance' and 'niche construction' in evolutionary biology (Odling-Smee et al., 2003; Oyama et al., 2001a). The phenomenon of mobility infrastructure and delivery systems can be seen as a particular manifestation of this wider dynamic. Haff (2010; 2012) points out that mobility infrastructure is not confined to the human and technological worlds: not just roads and railways but also rivers and animal paths are alterations of the environment which serve to reduce friction and/or 'form resistance' due to rough ground. But infrastructure is not just about energetics: *moving faster*, and more efficiently; it can also be about information and gratuity: *knowing where and how to move*. The ability of individual entities to move in complex ways on the Earth becomes an achievement not of that entity alone, but one built up through repeated motion within a 'taskscape' which is itself, in part, a sedimentation of all such prior movements (Ingold, 2000, p. 195).

Conclusion

The planets of our solar system move with what, at human timescales, seems like perfect regularity; *within* planets, by contrast, we find very different, 'sublunary' forms of mobility (Prigogine and Stengers, 1984, pp. 305–6). In the dense media of fluid planetary compartments, and under far-from-equilibrium conditions, the perfect, reversible god-like motion of the planets is all but impossible; inertia becomes not a form of memory but a source of forgetting, of dissipation, as moving entities diverge from their path in what Lucretius called the 'clinamen', losing not just their direction but their very motion in cascading eddies (Serres, 2000). Yet this forgetting also forms the basis of new and very different powers of motion and memory, just as it did in the early solar system as planets and moons formed themselves out of the solar nebula. The cascade of energy through the solar system and its constituent bodies generates new forms of self-organisation; the play between mixing and sorting, intensive difference and extensive form, means that as gradients are applied and dissipated, new gradients and new energetic levels are brought into being. Planets become historical entities, undergoing bifurcations in their development which condition their powers of motion and memory, and their possibilities for further development.

As we have seen in the case of the Earth, planets also develop their own 'mobility regions' within themselves; within these regions, material and energetic conditions give rise to particular possibilities for mobility. At different scales and speeds, mobile objects in these regions also inhabit different 'mobility situations', due to different balances of forces. Mobilities also 'tune' together – or even clash – as the delivery of matter, energy or information in one mobility system intersects with that of another. And sometimes these dynamics are 'locked-in' as historically contingent

bifurcations that condition the planet's future development, including its emergent powers of mobility.

I have also argued that complex features of technological mobility that might seem unique and unprecedented in the Earth can be understood as manifestations of a more general phenomenon of 'mobility gratuity', a relative uncoupling of different aspects of motion that can arise under planetary conditions. It may be true that the particular stabilisations and combinations of forms of gratuity that we see in technological mobility were partly driven by the contingent needs of human economies at particular times and places. However, viewed in the light of the long self-organisation of the solar system, they could also be seen as manifestations of more general powers of planetary mobility – and perhaps as hinting at radical new possibilities for its development, both here in the Earth and in other planets.

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Notes

[1] Mass action is of course not a wholly reliable indicator of the relative significance of different kinds of mobility occurring on a topologically complex planet or involving informationally rich entities.

[2] For an example of such an approach to estimating the likelihood of the emergence of 'intelligent life' or 'observerhood' on a planet, see Watson (2008).

[3] On forms of inscription and technological artefacts as an externalisation of memory, see Stiegler (1998).

[4] Baryonic matter is 'normal' matter, composed of atoms, as opposed for example to neutrinos or free electrons.

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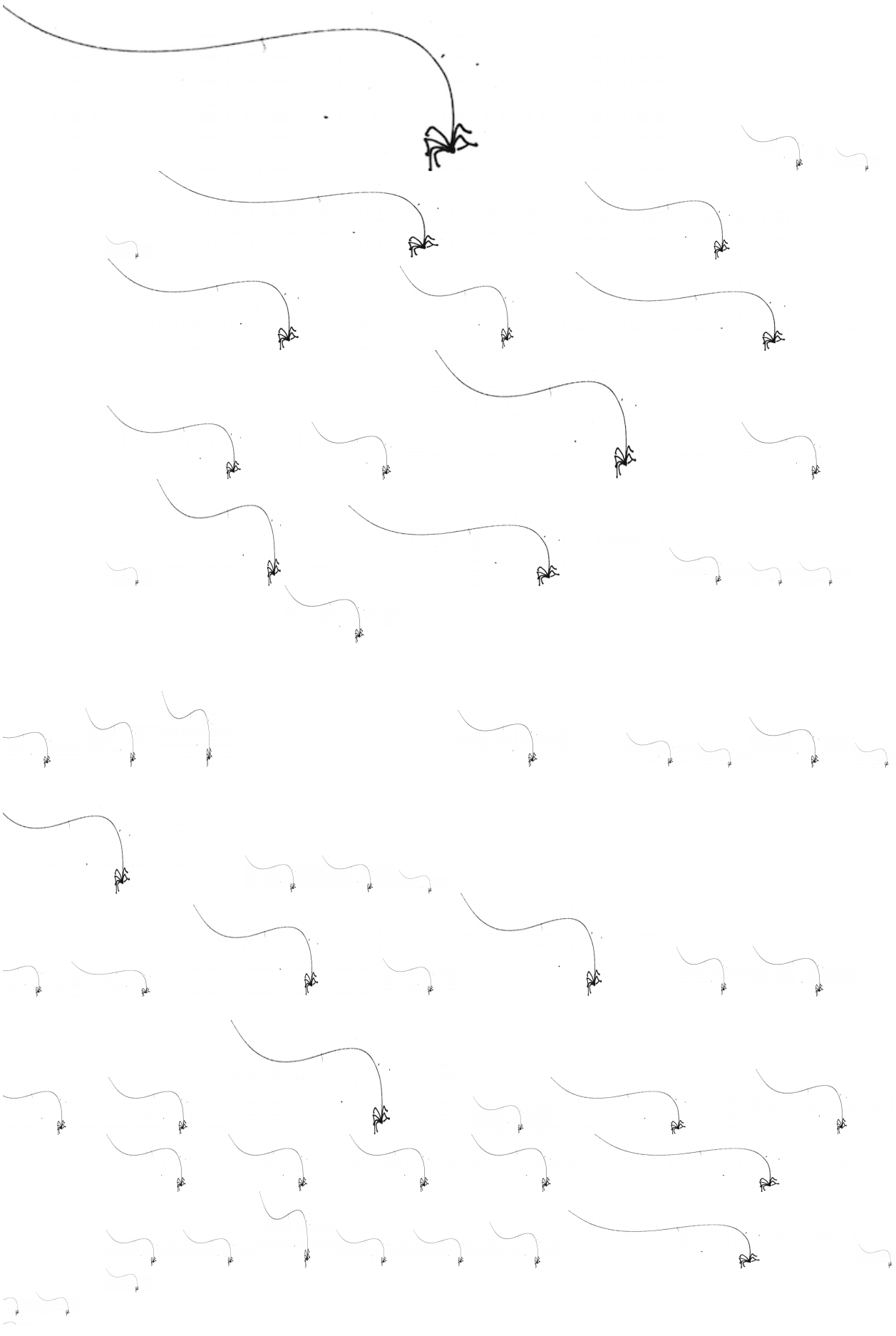

Sounding: *Echoes and Thresholds of Atmospheric Media*

(Chapter 6, from *Atmospheric Things: On the Allure of Elemental Envelopment*, by Derek P McCormack, forthcoming with Duke University Press)

To think of the volume of atmospheres is to invoke a sense of the sonorous. It is to allude to the fact that *how the force of the atmospheric sounds* is critical to *how it is sensed*, even when this sound is of a frequency or wavelength beyond the limits of human hearing and even when whatever is sensing this sound is not a human device.[1] It is hardly surprising perhaps that early aeronauts remarked frequently upon the sonorous qualities of the atmosphere in which they traveled, paying particular attention to how sounds were modified and modulated by the meteorological characteristics of the medium through which it moved. James Glaisher, notably, wrote that "fog is much more sonorous than dry air, and collects sound with such intensity, that whenever, in passing through a cloud, we have heard a band playing in a town beneath us, the music always seemed to be close at hand".[2] And, of a flight over London, he wrote: "when one mile high the deep sound of London, like the roar of the sea, was heard distinctly; its murmuring noise was heard at great elevations",[3] while at four miles, "the roar of the town heard at this elevation was a deep, rich, continuous sound – the voice of labour".[4]

The qualities of the echo aloft also fascinated aeronauts. Joseph Louis Gay-Lussac was a French physicist and chemist whose interest in balloon flight paralleled his scientific investigation of the properties of gases in the lab and in the air.[5] According to some accounts, on one flight Gay-Lussac brought a "speaking-trumpet" with which to experiment with sound. During the ascent, so an account of the ascent goes, Gay-Lussac noted that the "voice, through a speaking-trumpet, was re-echoed

most perfectly from the earth, even at the greatest elevation; and the time of the return of the echo so well coincided with their height, increasing in quickness as the latter diminished".[6] Apparently Gay-Lussac even suggested this interval could be used as an accurate measure of altitude, while also noticing that whenever he spoke into the trumpet "a slight undulation of the balloon was perceptible".[7] Or take the balloonist, astronomer, and writer Camille Flammarion. Like Gay-Lussac, Flammarion considered the echo a measure of altitude. But he noted also its aesthetic qualities: its "beauty" above a "wide sheet of water".[8] Of a flight near Paris in 1867, Flammarion wrote:

> "I shout: the sound returns as an echo, after a lapse of six seconds. It would be interesting to ascertain whether the vertical velocity of sound is equal to its horizontal velocity in the air, and if the echo is really returned from the plane beneath. […] I was much struck by the vague depth of the echo: it appears to rise from the horizon, and has a curious tone, as if it came from another world".[9]

Like others, Flammarion was also fascinated by the strange and profound experience of echo-less silence often characteristic of being in the air. Of the experience of being at 11,000ft, Flammarion wrote: "Absolute *silence* reigns supreme in all its sad majesty. Our voices have no echo. We are surrounded by a vast desert. The silence which reigns in these high regions of the air is so oppressive that we cannot help asking if we are still alive".[10] The absence of an echo seemed to reaffirm, for Flammarion, the existential reassurance provided by the return, resonance, or reverberation of sound. Without an echo, there was no palpable limit to the space in which the self was immersed nor any way of taking the measure either of that space or the self. Frances Dyson argues that when "immersed in sound, the subject loses its self, and in many ways, loses its sense".[11] But the converse is also true: without

sound, the spacing of the self becomes too expansive. The absence of echo points to the exposure of life to something beyond the reassuring envelope of the atmosphere, a realm in which the propagation of sound, as both a physical and existential process, is impossible. For Flammarion, the "imposing" silence pointed to whatever lay beyond the atmosphere, to the absence of a sonorous, audible signal, providing a "prelude of that which reigns in the interplanetary space in the midst of which worlds revolve".[12]

For these balloonists then, the echo was both an experiential phenomenon and a technique for experimenting with and within the atmosphere: in that sense it held together the volumetric and the voluminous dimensions of atmosphere. Its duration provided an index of measurable extent and calculable depth, while also generating a sonorous affective-aesthetic experience. Through minor experiments with the echo and its absence, these balloonists were *sounding* the atmospheric. To sound is to render something sonorous: to give it expressive, audible force, making it available for sensing. We often tend to think of this as a process involving distinctively human capacities. To sound, in these terms, is to vocalize something (but not necessarily to form it in words) that can be heard in the sensory loops and canals of human hearing.[13] But sounding does not necessarily involve the human body. Sounding, as a process of making audible, is abroad in the world. As Michel Serres reminds us, "in myriads, things cry out. Often deaf to alien emissions, hearing is astonished by that which cries out without a name in no language".[14] Furthermore, the source of this cry may not be a body nor an entity, but something far more diffuse: the buzzing, background noise of the world, or, beyond this, the refrain of the between of things, of a kind of original sonorous differentiation of the universe. Sounding begins, we might say, on the "threshold of the echo". [15]

To sound is also, however, to test, to explore the properties, qualities, or extent of a body of liquid. Deriving not from the sonorous, but from the old English word *sund*, meaning sea, sounding in a maritime or navigational sense involves a 'bathymetric' process of assaying the depth of the water in which a vessel floats. In its most simple iteration, it involves dropping a line over the side of a vessel in order to map the floor of a body of water. Today it is more likely to involve the use of an underwater echo (known as sonar). Derived from the maritime, this understanding of sounding is also used to describe the process by which the meteorological atmosphere is rendered explicit as a dynamic, turbulent zone. Sounding here involves the use of the balloon as a device with which to ascertain, remotely, and *in situ*, variations in atmospheric processes. The difference here, of course, is that the depth, or height, of the atmosphere (a least as taken from the surface) is not mappable in the same way as in the case of the sea. Nor is there a solid surface at the top of atmosphere against which to bounce a signal. Equally, with some exceptions, atmospheric sounding does not involve the use of tethered lines. Instead, for the most part it involves the release of free meteorological balloons into the atmosphere.

Taken together, these twin senses of sounding – as the process of making audible and making explicit – disclose atmospheres as a medium for particular kinds of media experiments. These are experiments linking the affective atmospherics of communication media with the idea of the atmosphere as an elemental milieu whose variations are messages can be discerned. They are experiments that stretch the envelope of possibility for transmitting and receiving messages as part of the engineering of increasingly global assemblages of communication. They are media experiments in which the dynamics of the meteorological atmosphere are disclosed through assemblages of objects and devices in the air and on the ground. But they are

also media experiments that, in certain circumstances, remind us that the force of the atmospheric is not just that which can be sensed through sounding, but is the very condition that makes particular kinds of sensing possible.

Soundings 1: Echo

In the late 1950s, NASA, AT&T, and Bell Labs began collaborating on the use of passive satellites for radio transmission under the name of Project Echo. The satellites used in the experiment were large, reflective balloons launched into low orbit to act, in effect, as huge spherical mirrors against which signals transmitted from one site could be bounced towards another. Something of the scope of the project, and of the structure of feeling within which it was undertaken, can be gleaned from *The Big Bounce*, an educational short film made about it.[16] The soundtrack of the film captures the atmospheric 'tone of the times' within which the project was undertaken.[17] The eerie music and the slightly portentous narration are strangely suggestive of something otherworldly, of the unfolding of an experiment mixing science fact and science fiction. The narrator begins: "the place, a hilltop in New Jersey. The setting, giant antennas, like monstrous eyes and ears, straining, watching, waiting". After outlining the nature of the experiment, the narrator observes that if it works "it will be the first time voice has travelled from the earth up to a man made moon, and back to earth again". The narrator then pauses to pose a question – "who cares about bouncing messages off a space balloon?" – before outlining the need for "more and different systems" through which to broadcast and continuously transmit radio and television signals.

Project Echo had its origins in various speculative proposals during the immediate post World War II period about the possibility of using balloon satellites as technical and to some extent geopolitical devices.[18] In 1946, the RAND Corporation

published its very first report, titled *Preliminary Design of an Experimental World-Circling Spaceship*, in which the possibility of using a balloon was considered briefly in the context of a range of other proposals.[19] In 1947, a follow-up report examined these issues further, proposing the use of satellites as reconnaissance devices. In the report, one of the members of the RAND team, James Lipp, had outlined a system of orbiting satellites and ground-based relay stations via which data could be transmitted beyond line of sight distances.[20] This proposal echoed, without acknowledging, ideas Arthur C. Clarke had articulated in a 1945 article about the value of a network of orbiting satellites for the global transmission of radio signals.[21]

In the early 1950s an electrical engineer at Bell Labs, John Pierce, also began thinking about a system of communication satellites orbiting the earth. Considering these ideas too far fetched for professional scrutiny, he chose to publish them initially in popular science fiction magazines. However, by the mid 1950s, he began publishing openly about the design of different kinds of satellites, ideas that would shape his practical experiments at Bell Labs. These experiments drew upon and drew together an assemblage of emerging technologies, including the transistor, the travelling wave tube, solar cells, and early kinds of laser, in addition to a type of antenna called the Horn antenna, which allowed microwave signals to be focused and received.[22] Combined with experiments with rocket engines then being undertaken by the Jet Propulsion Lab at NASA, the work at Bell Labs pointed to the development of satellites that could facilitate the transmission of strong and focused signals.[23] The ultimate goal of these experiments was the design and launch of active satellites that could both receive and transmit signals.

Project Echo was intended as a kind of incremental step towards the development of active satellites. It remained dependent upon a passive device

however, which could only receive a signal from a ground source and reflect it back to a large ground based antenna. Within this constraint, the aims of Project Echo were fourfold:

> "1. To demonstrate two-way voice communication between the east and west coasts by microwave reflection from the satellite.
>
> 2. To study the propagation properties of the media, including the effects of the atmosphere, the ionosphere, and the balloon.
>
> 3. To determine the usefulness of various kinds of satellite tracking procedures.
>
> 4. To determine the usefulness of a passive communications satellite of the Echo I type."[24]

The project involved a distributed assemblage of devices, including a transmitter in California and a receiver at Holmdel, New Jersey. At the centre of this assemblage was, however, a balloon. This had been designed at Langley air force base by William O'Sullivan, who conceived it initially as a sounding device of sorts, with which to "measure the density of the air in the upper atmosphere and thereby provide aerodynamic information helpful in the design of future aircraft, missiles, and spacecraft".[25] But O'Sullivan was aware also of the contribution that such balloons might make to the development of more extensive communication systems through which the technological, ideological, and affective dimensions of Cold War geopolitics might be amplified. Appearing before the House Select Committee on Science and Astronautics in April 1958, he enthused about the feasibility of launching such a balloon into orbit, claiming it "would reflect radio signals around the curvature of the earth using frequencies not otherwise usable for long range transmission, thus mostly increasing the range of frequencies for worldwide radio communications and, eventually, for television, thus creating vast new fields into which the

communications and electronics industries could expand to the economic and sociological benefit of mankind".[26] To reinforce his point further, during his visit to the committee he inflated a 12-foot foil-covered balloon satellite in the Capitol building.[27]

O'Sullivan faced particular challenges in designing and fabricating the envelope for this balloon: he needed a material light and compact enough to be launched into orbit in a rocket, strong and flexible enough to be inflated in orbit, and durable enough to withstand the rigors of heating and cooling in space. It also had to be reflective enough to be tracked from the ground. His solution was a laminate of two materials. The first was a new kind of very strong plastic film, Mylar, which had been developed recently by the DuPont Corporation and was also being used as an audio recording tape and in temperature resistant food storage bags. The second material was a thin aluminum foil developed by the Reynolds Corporation and applied through a vaporization technique. Even before the balloons were launched into orbit they provided reflective surfaces of captivation, and they conjured something of the allure of the envelopes with which those involved in later experiments at EAT would work. Inflated for testing in a hanger in North Carolina, the Echo balloon seemed to anticipate the reflective aesthetics of envelopment that would later take shape in the mirror dome of the Pepsi Pavilion, and, in a different way, in the foil covered envelopes of which Warhol's *Silver Clouds* consisted. This aesthetics can also be situated in relation to wider fascination in the US, during the late 1950s and early 1960s, with reflective metallic materials. This was a period during which aerial devices of all kinds, particularly military airplanes (to say nothing of chrome decorated cars), were fabricated from aluminum polished to the gleaming shine of what Mimi Sheller calls "light modernity".[28] In the period before disguise

and stealth became critical to aerial power, such new reflective materials provided surfaces for projecting an affective and geopolitical aesthetics of confidence.

O'Sullivan's balloons became the model for the satellites used in Project Echo. These were larger than those with which Sullivan had experimented initially, and as such, presented new technical challenges. During testing, the seams of the balloon were revealed to be too weak.[29] In addition, a series of test launches into the upper atmosphere were undertaken to examine how a second, strengthened balloon would cope with the rapid inflation of the envelope at this altitude. The first of these launches resulted in the destruction of the balloon when residual air in the folded envelope expanded explosively in the upper atmosphere. The problem was solved by using an inflation agent that transformed slowly but directly from a solid to gas (sublimation) and by making 300 holes in the envelope to allow air to escape.

One of the key difficulties face by the engineers was rather more mundane, and involved the problem of the relation between folding, envelopment, and inflation. Specifically, the problem was how to fold the balloon in such a way that it would fit inside a specially designed canister released from the rocket while also being free to inflate without tearing. Apparently, the solution to the problem was inspired by the design of a plastic rain hat owned by the wife of one of the project team. The work of learning to fold the fabric was described thus:

> "At Langley, Kilgore gave the hat to Austin McHatton, a talented technician in the East Model Shop, who had full-size models of its fold patterns constructed. Kilgore remembers that a "remarkable improvement in folding resulted." The Project Echo Task Group got workmen to construct a makeshift "clean" room from two by-four wood frames covered with plastic sheeting. In this room, which was 150 feet long and located in the large airplane hangar in the West

> Area, a small group of Langley technicians practiced folding the balloons for hundreds of hours until they discovered just the right sequence of steps by which to neatly fold and pack the balloon".[30]

The process of envelopment as one that involves folding and refolding is illustrated dramatically. The important of working with the capacities and limitations of this lustrous surface, and of tending carefully to the way in which this material behaved under a range of circumstances, were crucial processes through which devices for doing particular kinds of atmospheric things emerged.

Despite its first official launch ending in disaster, as a technical experiment Project Echo was a success insofar as it demonstrated the technical feasibility of passive satellite communication, becoming the first object in space against which a signal from the earth was transmitted and bounced.[31] After a second trouble free launch in August 1960, the Echo 1 balloon entered orbit around the earth at a speed of about 16000 miles an hour and at a height of approximately 1000 miles. During its first orbit the balloon relayed a message from President Eisenhower from California to New Jersey:

> "It is a great personal satisfaction to participate in this first experiment in communications involving the satellite balloon known as Echo. This is one more significant step in the United States' program of space research and exploration. The program is being carried forward vigorously by the United States for peaceful purposes. The satellite balloon, which has reflected these words, may be used freely by any nation for similar experiments in its own interest."[32]

The Echo balloon continued to orbit for well over eight years, during which time it facilitated experiments with satellite-borne two-way conversations and fax

transmissions. And while the launch of the Telstar satellite not long afterwards rendered the Echo satellite technically obsolete, it did have some important results, with both NASA and AT&T claiming that it was a critical experimental step in the development of global communication systems. In addition, as it continued to orbit for eight years, "the satelloon allowed scientists to measure accurately, for the first time, the density of the air in the far upper atmosphere", and to ascertain how this density was modified by solar activity.[33] Project Echo was also followed up by a series of similar launches under the name of Explorer, launches that generated further data about atmospheric density. In addition, in 1966, the "Pageos" balloon was launched as part of a 5-year project involving 12 mobile tracking stations in order to provide precise data about the shape and size of the earth.[34]

The Echo balloons were orbiting satellites rather than more conventional atmospheric sounding balloons. But they can be understood as sounding experiments of a sort insofar as they were critical to efforts to gauge, and in some sense stretch, the limits of the envelope of modern forms of communication. The echoing, or bouncing, of the signal against the reflective surfaces of the Echo balloons was therefore a critical moment in the emergence of contemporary infrastructures of atmospheric sounding.[35] Even if these infrastructures were not all about the transmission of the voice, in the bouncing of Eisenhower's message against the envelopes of the Echo balloons, the dream of a global media atmospherics was sounded with particular clarity, Project Echo was a pilot experiment for the development of distinctive kinds of media infrastructure that was simultaneously technical, geopolitical, affective, and atmospheric. The launch of the Echo balloons pointed to the emergence of assemblages of media transmission that could connect distant places in novel ways but also, in doing so, could modulate the affective atmospherics of the Cold War.[36]

They captured in their shape the promise of connectivity and immediacy through infrastructures that linked devices in orbit with an expanding array of technologies on the ground. The visibility of these objects from the ground contributed to the affective atmospherics that accompanied the prospect of seeing something in the sky in the context of the Cold War. Against the backdrop of the launch of the Soviet Sputnik satellite a few years earlier, the Echo satellites became objects of affective allure in a world becoming sensitized to the presence of new kinds of devices orbiting the earth. The psychological and political benefits of such a satellite program had been identified in the 1945 RAND report. Anticipating the surprise that would accompany the Sputnik programme a few years later, in the conclusion to the RAND report, Lipp wrote noted that "one can imagine the consternation and admiration that would be felt here if the United States were to discover suddenly that some other nation had already put up a successful satellite".[37] The symbolic and affective value of launching something visible into near space had also been earlier anticipated by a chemist, Aristid Grosse, of Temple University who, in a report for the Truman administration, had "recommended orbiting an inflatable balloon that would, to the naked eye, appear as an "American Star" rising in the West".[38] The designer of the ECHO balloon, O'Sullivan, had been similarly enthusiastic about the political significance of his satellites. He had earlier proposed launching into space a 12-foot inflatable sphere known as Beacon for the sole purpose of getting some kind of object in orbit that might be visible to the naked eye over Russia.[39]

It is hardly surprising that even the testing phase of Project Echo generated interest amongst a public primed to anticipate the possibility of seeing artificial things in orbit. When the balloon had exploded during the process of inflation on an earlier test launch, thousands of pieces of the aluminized Mylar floated back into the

atmosphere, "reflecting the light of the setting sun", and creating "sensational flashing lights" in the sky all along the Atlantic seaboard.[40] Rather than reporting the failure press releases about the launch emphasized the success of launching object into space, and newspapers feature headlines such as "Earthlings stirred by NASA Balloon, Awesome Sight in the Sky".[41]Such interest was heightened once the Echo balloon entered orbit. Visible from the ground, these orbits became the focus of curiosity and wonder, amplified by its appearance in newspapers and magazine.

Soundings 2: GHOST

Later in the decade, on October 1st 1968, the National Centre for Atmospheric Research, based in Boulder, Colorado, issued a press release under the following heading:

> "GHOST Balloon completes One-Year Flight"

The press release announced that a "ten-foot plastic balloon, launched from New Zealand in September 1967, has just broken all previous balloon flight-duration records by staying in the air for one year."[42] During that year the balloon, fabricated from Mylar, had circumnavigated the southern hemisphere 25 times at a constant height of about 52,000ft, its signals tracked by various stations.

The record-breaking flight was made by one of over 80 balloons launched from Christchurch, New Zealand, as part of the GHOST (Global Horizontal Sounding Technique) project. Involving a scientific collaboration between NCAR (along with other agencies in the US) and agencies in New Zealand, the central aim of the GHOST project was to test the feasibility of using balloons to provide accurate real time information about the atmosphere in ways that were previously impossible. In effect, the balloons were intended to act as "roving weather stations which can collect

atmospheric data to be used in global weather forecasting". This data was to be used, the press-release continued, to aid the development of "numerical models of the atmospheric general circulation, which will be used to forecast weather by making it 'happen' in the electronic circuits of a computer faster than it happens in the real atmosphere".[43] The team at New Zealand was led by Vincent Lally, who had for some years experimented with balloons as devices for measuring atmospheric phenomenon. Instrumental in setting up the balloon research division of NCAR, Lally had developed, among other things, super-pressure balloons that could maintain a constant altitude by floating at a specified atmospheric density.

Collecting atmospheric data via vertical balloon sounding had been undertaken for decades. Indeed, the atmosphere in a meteorological sense was gradually disclosed by the use of balloon sounding. The first experiments with unmanned balloons as devices for studying the upper regions of the atmosphere were undertaken in France in 1892 by Hermite and Besancon in France, who launched recoverable recording instruments including a thermometer, barometer, and hygrometer. Very quickly, the use of such instruments facilitated the identification of the stratosphere, with a range of other balloon types devised in the years following. A persistent problem faced by those who used such balloons, however, was the difficulty of their recovery. The invention of the radiosonde in 1929 changed this. This involved the addition of a radio transmitter to weather balloons that allowed the transmission of real time data on wind, pressure, temperature, and humidity.[44] Equally, the development of new plastics from which to construct envelopes facilitated the development of more extensive scientific ballooning during the 1950s and 1960s. The GHOST project emerged in this context, as an ambitious experiment in horizontal sounding, via which data about wind, temperature and humidity could be

collected as balloons circulated in the upper atmosphere.[45] The super-pressure balloons it deployed were fabricated from strong, inelastic plastic. They were also equipped with transmitters and, importantly, with 'cut-down' devices that could be triggered should the balloon drift over geopolitically sensitive territory or through the wrong airspace.

To reduce the likelihood of such incursions, a project launch site was established in Christchurch, New Zealand. Lally, his team, and indeed some of their families, moved to Christchurch. As with Project Echo, much of the work of the GHOST project involved devising ways of fabricating, inflating, and launching the balloons. Equally, the families of the project scientists and technicians sometimes became involved in the GHOST operations, albeit in ways that were perhaps more participatory.

Like Project Echo, GHOST also involved the development of a distributed assemblage of devices for sounding and listening, but one that was more obviously international in its scope and level of cooperation. Once they were launched, the work of sounding the upper atmosphere involved listening out for the balloons, each of which was identified by the sound of the distinctive signal (of dots and dashes) it had been assigned. This was facilitated via a network of listening posts and tracking stations scattered across the southern hemisphere at sites in Angola, Antarctica, Argentina, Australia, Brazil, French Polynesia, Mauritius, South Africa and Zambia. On one level, this experiment in sounding and listening was a technical operation involving the tracking of technical objects. But as with those who travelled in balloons aloft, the experience of working with balloons that are then released independently into the atmosphere is also an affective one. These devices become alluring objects whose existence, once launched, became more spectral than merely

the title of the project suggested. This was intensified as the movement and trajectories of the balloons faded in and out of the range of different listening posts, variously withdrawing into and re-emerging from an undisclosed atmospheric zone, particularly over Antarctica. Lally's notes hint that the periodic disappearance and surfacing of the balloons was felt affectively. In some cases the signal heard was difficult to discern, with the result that the status of various balloons sometimes remained shadowy and approximate at best. On February 8th, 1966, for instance, Lally noted that he had "[f]ound mysterious balloon at 15.022", and that this was "GHOST" of M". On May 8th, he noted that the team was "unable to hear FFF today except faint background – apparently deep in Antarctic". On May 14th, his notebook read: "Long lost 23206 FFF came back!!!"[46] For Lally and his team, then, sounding not only involved using the balloon as a device for sensing *in situ* the atmospheric field in which it moved. It also mobilized sounding as an affective process of distributed listening for something spectral: of listening for the signal of super-pressure balloons as they called out their position while circumnavigating the southern hemisphere.

Lally imagined GHOST as the precursor to a more ambitious project, which would include "5000 to 10,000 Ghost balloons, roving freely above the globe at predetermined levels of the atmosphere". Because it would simply be too costly, too logistically difficult, and too politically complicated to try to build a network of ground-based receiving stations, data from these balloons would not be transmitted directly to the ground, but would be relayed by "two or more earth-orbiting satellites".[47] The overall aim would be to provide a system for generating immediate, real-time information about the state of the atmosphere, data that could be used by increasingly powerful computers to generate more reliable weather forecasts. Framed by the geopolitical tensions of the Cold War and technological optimism of the post-

war period, the GHOST project was to be a precursor to a distributed assemblage of devices, including balloons, satellites, and sea buoys, through which the dynamics of the meteorological atmosphere could be sounded on an ongoing, long-term basis.

Lally's hope was that the requirement to understand the dynamics of the weather would generate the imperative to form new kinds of international co-operation. To some extent these hopes were realistic: a range of such co-operative experiments were undertaken during the 1960s and 1970s, generating a system of progressively more global reach for understanding the dynamics of the atmosphere and weather. Nevertheless, in notes for a lecture on the promise and problems of a project such as GHOST, NCAR's Vincent Lally wrote that the acquisition of upper air data:

> "Turns out to be a global problem and a sticky political problem. However, we know the problems and have solutions in mind. Let's hope that in the next few years we shall be negotiating for the placement of balloon launch sites instead of the removal of missile launch sites".[48]

Indeed, even over friendlier territories the GHOST balloons became objects around which the geopolitical affects of the Cold War could crystallize. According to the *Christchurch Star* of August 1969, the population of the small Queensland town of Milmerran mistook one of these balloons for a UFO. A Canberra bomber investigated the sighting, and confirmed that the object was "a huge transparent bubble".[49]

As an experiment in meteorological sounding, the GHOST project was an exercise in making the dynamics of the atmosphere explicit. But it is also a reminder that these projects are media experiments of a sort because they bring the dynamics of the atmosphere within the orbit of a range of media techniques and experiences. As Jussi Parikka has observed, "practices of meteorology are mediatic techniques that

give a sense of the dynamics of the sky".[50] GHOST anticipated a network of listening devices with would underpin the promise of providing more effective prediction of the weather in the media worlds of everyday life. However, where Echo balloons were premised on the possibility of rising above the atmosphere in order to expand the envelope of atmospheric media nearer to the ground, the GHOST balloons moved with the trajectories of the atmosphere, particularly the stratosphere. As such, they point to something else: to the possibility of using the movement and variations in the atmosphere as infrastructural trajectories for the distribution of devices, ideas, and affects.

Soundings 3: Scattering

Sounding travels across and between GHOST and Echo. In the GHOST project, sounding is a technique for assaying the meteorological dynamics and properties of the elemental atmosphere. In Project Echo sounding is the process through which voice transmission provides an indicator of the technical viability of new forms of infrastructure that, even if they operate in part above the atmosphere in a meteorological sense, facilitate the development of envelopes of atmospheric media in terrestrial life-worlds. We might say, then, that sound is the both the process by which the dynamics of the atmosphere are disclosed and the process by which the limit, or envelope of atmospheric sensing is stretched.

But how far might this envelope be pushed? What if we return to the speculations of Camille Flammarion, noted at the outset, about what exists beyond the realm of the air or atmospheric? How might the silence of the 'vast desert' beyond, move us to ask other questions about the limits and thresholds of sounding the atmospheric? Questions about what it means to sound something whose origin is beyond the atmospheric envelopes in which life on earth is immersed. As it turns out,

the balloon has for quite some time provided an platform for undertaking experiments designed to address such questions, and in particular through research on cosmic rays. During 1911 and 1912 the Austrian scientist Victor Hess made a series of balloon ascents to explore how radiation ionized the earth's atmosphere. On one of these ascents he realized that even during a solar eclipse the process of ionization continued within the atmosphere, penetrating through its lower layers, but remaining significantly greater in the upper atmosphere: Hess concluded from this that the source of this radiation must be extra-terrestrial. This 'discovery' was not universally accepted, however. Further balloon experiments during the 1920s and 1930s confirmed their existence, including those by Robert Millikan, who used unmanned sounding balloons, having acquired experience of their use during World War 1.[51] It was Millikan who gave the name 'Cosmic Rays' to this radiation.

So a simple device like the balloon can provide a platform for sensing something whose origins are extra-terrestrial. The properties of cosmic rays continued to be investigated in this way throughout the 20th century, remaining central, for instance, to the US Skyhook and Strato-Lab programs in the decades after World War II. [52] Crucially, the aim of such experiments is not to sense the dynamics of the atmosphere: instead, the atmosphere becomes a medium for sensing something whose origin is excessive of the category of atmosphere, something which is only sensed through its capacity to generate a form of elemental perturbation in a medium like air, water, or other materials. We can think of this as another form of sounding: a form of sounding the force of something excessive of atmosphere.

Another experiment allows us to think further about this. While it does not involve a balloon, the site at which it took place, and the device used, were central to the infrastructural assemblage that facilitated Project Echo. The device in question is

the Horn Radio Antenna at Holmdel, New Jersey, constructed in 1959 as part of Project Echo, and taking its name from a parabolic horn-shaped structure with a curved aperture at its open end. The antenna is about 50 feet long and can be rotated such that it points towards any part of the sky. Critical to its operation in Project Echo was the use of a MASER (Microwave Amplification by Stimulated Emission of Radiation) that allowed very weak microwave signals to be amplified without adding any noise.[53]

In the early 1960s, two physicists at Bell Laboratories – Arno Allan Penzias and Robert Woodrow Wilson – were tasked with the rather routine task of measuring the sensitivity of the Holmdel antenna, with the agreement that they could then use it for astronomical observation.[54] During their work Penzias and Wilson encountered a problem, however. Try as they might, they could not eliminate a persistent and steady noise continuously present at the frequency of microwaves, something like the "hiss that an old FM receiver might have made with an unused channel".[55] Penzias and Wilson were perplexed, but continued trying to identify the source in order to eliminate it from their calibration of the telescope. Examining the antenna, they removed pigeon droppings and pigeons (which were shot) in the hope that either may have been the source of the signal, but with little effect. The hissing noise continued, apparently without any discrete source, "and seemed to be coming from somewhere outside the atmosphere".[56]

After eliminating the possibility of any human source for the signal, including the nearby New York City, Penzias and Wilson eventually began to speculate that its origins were cosmic. Consulting colleagues, they came to the conclusion that the noise was the signature of cosmic microwave background radiation (CMB). The existence of CMB radiation had been theorized for some time as the thermal signature

of the initial generative event from which the universe emerged (now commonly known as the big bang). The oldest light in the universe, sometimes known as relic radiation, it is only really detectable in the microwave range by the kinds of sensitive antenna with which Penzias and Wilson were working. Other teams were searching for it at the same time as Penzias and Wilson made their discovery, and after consulting them, both teams published simultaneous notes with Penzias and Wilson.[57] However, notwithstanding the fact that theirs was an entirely accidental discovery, Penzias and Wilson were subsequently awarded a Nobel Prize for their work.

It is easy to understand this as a physics experiment even if the details of the physics are difficult to grasp. But no less than Project Echo and Project Ghost, this experiment, perhaps like all astronomical experiments, can also be understood as a media experiment: it is an experiment that poses the question of how forces excessive of our envelopes of atmospheric experience can be disclosed through making a range of materials into media for sensing these forces. Admittedly, as an experiment that involved a device for listening to an extra-terrestrial signal, the work of Penzias and Wilson was by no means unique. There are comparisons here, for instance, with the experiments by Dame Jocelyn Bell Burnell (under the supervision of Anthony Hewish) with a 4-acre radio telescope with which she detected the existence of pulsars. However, the Holmdel experiment differs because unlike Bell Burnell's experiment, the source of the signal could not be identified with any specificity or clarity.

Penzias and Wilson's is also a media experiment, however, because it poses the question of what it is to sense something whose signal comes from all directions all at once. It is an experiment that foregrounds with particular acuity the question of whether the source of such a signal can be sounded out in terms of an entity or object.

Certainly, this kind of sounding might be understood as a technique disclosing entities whose scale and duration is beyond the scope of any human frame of reference. CMB radiation could be the signature, afterglow, or relic of what Timothy Morton calls a hyper-object: an entity so vast and massively distributed that it cannot grasped within human frames of perceptual and conceptual reference.[58] CMB does not need to be grasped in terms of an entity, however. Indeed, one of the remarkable aspects of the experiment by Penzias and Wilson is that what is sensed in this case is not an entity, but something excessive of this category, something subsisting between cosmic bodies, between planets, stars and galaxies, something between worlds.

Rather than an entity, the Holmdel Antenna sensed a kind of thermal background persisting as the after-affect of a singular event. But it did not sense this thermal background as atmospheric, and for at least two reasons. First, the idea of the atmospheric suggests the presence of a medium in the absence of which affects and sounds will not propagate: CMB, in contrast, can be detected as a kind of background extra-atmospheric acoustic oscillation in matter. Second, the concept of the atmospheric is suggestive of a medium of variable intensity that can be backgrounded and foregrounded to different degrees. But CMB cannot be foregrounded. It remains in, or precisely as, background, without crossing a threshold such that it becomes palpable as an immersive medium.[59] Because of this, CMB is more properly understood in terms of the ambient than the atmospheric. The ambient, as distinct from ambience, which refers to the sensory qualities of spacetime from a human point of view, remains a diffuse, low intensity background.[60] The ambient does not draw attention to itself: it is itself interstitial to attention. In the case of CMB, the ambient is heat and light, the afterglow of an event from which all entities emerge, but which does not itself become an entity.

If it is excessive of the circumstantial specificity of terrestrial atmospheric things, the shape of this ambient background can still be understood in terms of an envelope, or surface, at least of a sort. This is a surface that is always receding from the observer, listener, or sensing device. The shape of the ambient is the shape of a period of recombination, taking place after the big bang, during which the universe cooled and electrons began to combine to form atoms, leaving photons to move freely. Peter Coles explains it thus: CMB radiation "appears to come from a spherical surface around the observer such that the radius of the shell is the distance each photon has travelled since it was last scattered at the epoch of recombination. This surface is what is called the last scattering surface".[61] Beyond this surface, everything is ionised in an opaque but bright fog. Coles offers another way of thinking of this surface, not as one of scattering, but as a surface of last screaming, the sound of which is the furthest in time and space from the observer that can be sensed.

Cosmologically, then, the significance of what Penzias and Wilson did was to provide evidence for the existence of the ambient heat and light of the cosmic, paving the way for confirmation of the expansionist theory of the universe. But the significance of this experiment as a media experiment is rather different: by converting ambient light and heat into sound – by sounding the ambient – they transformed the afterglow of an event into something that could be sensed as atmospheric: the atmospheric, in this context, became the threshold over which something ambient could be sensed rather than the signature of an entity. In the process, by sounding this signal through the familiar hiss of atmospheric radio static, the Holmdel experiment extended the limit of the envelope of media sensing: it extended this beyond the arc of the gaseous atmosphere into the ambient cosmos. The experiment by Penzias and Wilson was, then, among other things, a media experiment

in sounding, in sounding the limits of that which can be sensed as a signal. Following Michel Serres, we might call this signal the background noise of all media, the elemental media signature of a sonorous and luminous cosmos.[62] This signature is the ongoing refrain of an event whose afterlife might be grasped as the envelope of all envelopes.

Atmospheric Sounding for Elemental Media Studies

Despite the development of a range of devices and sensing arrays, the balloon remains valuable as a device for sounding the cosmological, not least because it is relatively cheap.[63] A series of balloon-borne sensing projects (TOCO, BOOMERanG, and MAXIMA) begun in the late 1990s were used to detect what Bassett, Nichol and Eisenstein call "acoustic oscillations' in the distribution of radiation and matter in the universe" as part of the project to map the Cosmic Microwave Background. These projects produced new maps of the sense-able universe defined not so much in terms of entities but in terms of gradients, oscillations, and density fluctuations.[64] In doing so, the flights of stratospheric balloons drew together the kinds of practical experiments of Lally and his GHOST project with the cosmological orientation of the experiments by Penzias and Wilson. They pointed to the ongoing value of experiments with atmospheric assemblages, combining devices in the air and on the surface of the earth, for trying to sound whatever Camille Flammarion had speculated might "reign in the interplanetary space in the midst of which worlds revolve".[65]

Such experiments are part of the ongoing process of sounding the volume(s) of spacetimes in ways that hold together different senses of media and medium: they hold together media as message transmission, media as medium through which messages move, and medium as vessel or container. To experiment with sounding is

therefore to undertake a mixed media experiment of sorts. These are mixed media experiments that both reveal and stretch the atmospheric as a field of sensed variation in assemblages of devices and bodies of different kinds. In the case of the GHOST project this involves using the balloon as a vehicle with which to assay the qualities of the atmosphere as the medium through this vehicle moves. In the case of Project Echo it involves using the balloon as a surface against which radio signals can be reflected. In the case of the work by Penzias and Wilson, since developed further by experiments with stratospheric balloons and satellites, it involves sounding the signal of all signals, the cry of the cosmos as that which is always excessive of entities. Taken together, these are media experiments that disclose the very limits of the atmospheric as an envelope of sensed variation, the limits of what Frances Dyson calls the "reverberative atmosphere that surrounds, encloses, shapes, and sustains us".[66]

Sounding then, is an experiment in sensing variations and patterns in the atmosphere, and of foregrounding the condition of becoming atmospheric as an important threshold of that which can be sensed. Experiments with sounding point us towards a kind of extended media studies that is as much meteorological and cosmological as geological in orientation, a media studies that listens out for the refrain of that which is beyond the cry of the earth.[67] In some cases, this involves the use of various devices, including the balloon in its various incarnations, to pursue what Sasha Engelmann calls a "more-than-human" form of "affinitive listening" to the oscillations of the atmosphere as an envelope of sensible variation.[68] But this is also a kind of media studies whose attention is directed to the possibility of a sound or signal that requires no atmospheric medium, which in this case is the signature of the ambient light and heat between things. Listening, or becoming attuned to these signals

is not so much about the search for alien life, but about rendering sonorous the extra-terrestrial. Nevertheless while moving beyond the geological to the cosmic this kind of sounding is facilitated by a range of earthbound devices. Indeed, the earth itself might be becoming a device for such sounding, as we become more aware of the capacities of different materials from which it is composed to sense variations in previously unheard of particles. As Jol Thomson and Sasha Engelmann suggest, these experiments involve using the material of the earth as a listening, sounding, or detecting device with which to pick up the traces of elemental particles that in any other circumstance could not be rendered present because they pass through things without mediating or being mediated by those things.[69] Here, the scale of sounding and listening goes far beyond the human body and the devices around with which it is surrounded, but extends to massive devices designed to detect infinitely small perturbations in spacetimes.

All this suggests that it is necessary to develop a much wider conception of media studies, and of media geography, through which to grasp how the circumstances under which the atmospheric comes to matter. The field of this sounding is far more expansive than the traditionally circumscribed spaces of acoustic phenomenology, and extends to the materialist question of how to pick up the traces of a vibrational milieu in excess of human capacities to sense.[70] Following thinkers like John Durham Peters, we might think of this as a kind of elemental media studies concerned with exploring how far the relation between sensing and medium can be stretched via experiments with different devices.[71] This form of media studies would be concerned with, amongst other things, how forms of envelopment, whether the body, the balloon, the antenna, or the earth itself, provide sounding devices through which the atmospheric is both an earthly elemental condition for sensing and the

threshold across which something more than earthly must pass before it can be sensed. This would be a media studies concerned with experimenting with sounding – in all aspects of that term – the limits of the envelope of possible sensing. Importantly, this limit is not necessarily defined in terms of the allure of an entity whose essence (as something unified) is to be withdrawn from us. Rather, it is the limit of an envelope that never takes the form of an entity, but takes shape, however dimly, as a shimmering, screaming surface always receding from whatever senses towards it.

Notes

[1] For an excellent discussion of the relation between sound, atmosphere, and envelopment, see Frances Dyson, *Sounding New Media: Immersion and Embodiment in the Arts and Culture* (Berkeley: University of California Press, 2009).
[2] In James Glaisher, ed. *Travels in the Air,* 2nd Edition (London: Richard Bentley and Son, 1871), 174.
[3] In Glaisher, *Travels in the Air,* 79.
[4] Ibid., 79.
[5] Gay-Lussac's law, formulated first in 1802, states that when the volume and mass of a gas remain constant then the pressure of that gas will increase with temperature. In addition to first recognizing iodine as a distinct element, Gay-Lussac, with Alexander Von Humboldt, also observed that the composition of the atmosphere does not vary with altitude. In pursuit of this understanding of the quality of atmosphere and to investigate the strength of the earth's magnetic field at altitude, Gay-Lussac undertook a balloon flight with Jean Baptiste Biot in August 1804.
[6] From C.J.S., "A Series of Letters on Acoustics, addressed to Mr. Alexander, Durham Palace, West Hackney", *The Gentleman's Magazine* 111, part 2 (February 1812): 105-110, 110.
[7] C.J.S, "A Series of Letters", 110.
[8] Camille Flammarion, in James Glaisher ed., *Travels in the Air,* 2nd Edition (London: Richard Bentley, 1871): 160-161, 2.
[9] Ibid., 128.
[10] Ibid., 147.
[11] Dyson, *Sounding New Media*, 4.
[12] *Travels in the Air*, 148. See also Camille Flammarion, *L'Atmosphère: Météorologie Populaire* (Paris: Hachette, 1888). Flammarion's speculations anticipate later ideas about the limit of an atmospheric envelope of sonic experience and materiality, including, notably, Antonin Artaud's "There is No More Firmanent", in *Collected Works, vol. 2*, translated by Victor Corti (London: Calder and Boyars, 1971). For a discussion of Artaud's work, see Dyson, *Sounding New Media*.
[13] On the relation between sound and the voice, see Anja Kanngieser, "A Sonic Geography of Voice: Towards an Affective Politics," *Progress in Human Geography* 36, no. 3 (2012): 336-353. On the relation between sound, experience, and spatiality, see George Revill, "How is Space Made in Sound? Spatial Mediation, Critical Phenomenology and the Political Agency of Sound," *Progress in Human Geography*, forthcoming.

[14] Michel Serres, *The Five Senses: A Philosophy Of Mingled Bodies*, trans. Margaret Sankey and Peter Cowley (London: Athlone, 2008), 141.
[15] Michel Serres *Genesis*, trans. Genevieve James and James Nielson (Ann Arbor: University of Michigan Press, 1995), 119.
[16] *The Big Bounce*, Jerry Fairbanks Production, 1960.
[17] I adapt this phrase from the title of Frances Dyson's book. See Frances Dyson, *The Tone of Our Times: Sound, Sense, Economy, and Ecology* (Cambridge, MA: MIT Press, 2014).
[18] For an account of the role of satellites in the expansion of media worlds, see Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham, NC: Duke University Press, 2005).
[19] "Preliminary Design of an Experimental World-Circling Spaceship", Report No. SM-11827 (Santa Monica, CA: Douglas Aircraft Company, INC, 1946).
[20] See Davies and Harris, "RAND's Role in the Evolution of Balloon and Satellite Observation Systems, and Related US Space Technology" (Santa Monica California: The Rand Corporation, R-3692-RC, 1988), 16.
[21] Arthur C. Clarke, "Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?" *Wireless World* 51 (1945): 305-08.
[22] John Gertner, *The Idea Factory: Bell Labs and the Great Age of American Invention* (London: Penguin, 2012).
[23] William Jakes, *Participation of Bell Telephone Laboratories in Project Echo and Experimental Results: Technical Note D-1127* (Washington: NASA, 1961).
[24] Jakes, *Participation of Bell Telephone*, 1.
[25] "The Odyssey of Project Echo", *SP-4308 Spaceflight Revolution* (Washington, DC: NASA History Office, undated), 156.
[26] "The Odyssey of Project Echo", 176.
[27] Ibid., 176.
[28] Mimi Sheller, *Aluminum Dreams: The Making of Light Modernity* (Cambridge, MA: MIT Press, 2014).
[29] Image available here, http://www.corp.att.com/attlabs/images/echo.jpg.
[30] "The Odyssey of Project Echo", 188.
[31] Strictly speaking, the Echo balloon was not the first surface against which voice signals had been bounced. In 1954 the US Navy began experimenting with the use of the moon as a surface against which to reflect voice transmissions. See Helen Gavaghan, *Something New Under the Sun: Satellites and the Beginning of the Space Race* (New York: Springer, 1998). On the relation between space and media see Katarina Damjanov, "The Matter of Media in Outer Space: Technologies of Cosmobiopolitics," *Environment and Planning D: Society and Space* 33, no. 5 (2015): 889-906.
[32] Transcribed from *The Big Bounce*, 1960. See also "The Odyssey of Project Echo", 188.
[33] "The Odyssey of Project Echo", 191. See John Pierce, "Satellite Science and Technology," *The Observatory* 83 (1963): 207-216.
[34] Ibid., 192.
[35] See Dyson, *The Tone of Our Times*.
[36] On this see Joseph Masco, *Theatre of Operations: National Security Affect from the Cold War to the War on Terror* (Durham, NC: Duke University Press, 2015).
[37] Davies and Harris, "RAND's Role", 17.
[38] Davies and Harris, "RAND's Role", 42.
[39] "The Odyssey of Project Echo", 176.
[40] "The Odyssey of Project Echo", 153.
[41] "The Odyssey of Project Echo", 155.
[42] "GHOST Balloon Completes One-Year Flight", *National Centre for Atmospheric Research*, Boulder Colorado, October 1 1968, page 1. Available at http://nldr.library.ucar.edu/repository/assets/info/INFO-000-000-000-105.pdf. Last accessed June 4 2014.
[43] "Ghost Balloon Completes One-Year Flight", page 2.

[44] See Jean Pierre Pommereau, "Observation Platforms: Balloons", in J. Holton, J. Pyle and J. A. Curry, eds. *Encyclopedia of Atmospheric Sciences* (Waltham, MA: Academic Press, 2003): 1429-1438.
[45] Vincent Lally Collection, Boulder, CO: National Center for Atmospheric Research.
[46] Vincent Lally Collection, Boulder, CO: National Center for Atmospheric Research.
[47] "Ghost Balloon Completes One-Year Flight", 2.
[48] From the Vincent Lally Collection, *Archives of the National Centre for Atmospheric Research*, Boulder, Colorado.
[49] From the Vincent Lally Collection, *Archives of the National Centre for Atmospheric Research*, Boulder, Colorado.
[50] Jussi Parikka, *A Geology of Media* (Minneapolis: University of Minnesota Press, 2015): 12-13.
[51] For a discussion of the fraught, complex, and contested 'discovery' of cosmic rays, see Charles Ziegler, "Technology and the Process of Scientific Discovery: The Case of Cosmic Rays," *Technology and Culture* 30, no. 4 (1989): 939-963.
[52] See Qiaozhen Xu and Laurie Brown, "The Early History of Cosmic Ray Research," *American Journal of Physics* 55, no. 23 (1987): 23-32.
[53] Gavaghan, *Something New Under the Sun*.
[54] Stephen Webb, *Measuring the Universe: Cosmological Distance Ladder* (New York: Springer, 1999), 270.
[55] Geoff Brumfiel, "Big Bang's Ripples: Two Scientists Recall Their Big Discovery", *NPR*, May 20, 2014, http://www.npr.org/2014/05/20/314239930/big-bangs-afterglow-two-scientists-recall-their-big-discovery. Last accessed, Aug 14, 2015.
[56] Arno Penzias, transcribed from "The Violent Universe: The Holmdel Horn Antenna", *BBC films*, available at http://www.bbc.co.uk/science/space/universe/scientists/arno_penzias_robert_wilson#p00bf13x, last accessed 14 08 2015.
[57] See Arno Penzias and Robert Wilson, "A Measurement of Excess Antenna Temperature at 4080 Mc/s," *Astrophysical Journal* 142 (1965): 419-421.
[58] Timothy Morton, *Hyperobjects: Philosophy and Ecology After the End of the World* (Minneapolis: University of Minnesota Press, 2013).
[59] On this point I differ from Timothy Morton's depiction of an 'ambient poetics' which he claims is characteristic of ecomimesis. While I agree that the ambient can refer to something "material and physical, though somewhat intangible", I don't we need to inevitably think of it in terms of "world". Nor am I so dismissive of various aesthetic practices, including those that figure in this book, which experiment with the possibility of some sense of a surround. See Timothy Morton, *Ecology Without Nature: Rethinking Environmental Aesthetics* (Cambridge, MA: Harvard University Press, 2007), 33.
[60] On ambience as the felt quality of space from a phenomenological point of view, see, Jean Paul Thibaud, "The Sensory Fabric of Urban Ambiances," *Senses & Society* 2, no. 3 (2011): 203-215.
[61] See Peter Coles, *The Routledge Critical Dictionary of the New Cosmology* (New York: Routledge, 1999), 244.
[62] Serres, *Genesis*.
[63] Bruce Bassett, Bob Nichol, and Daniel Eisenstein, "Sounding the Dark Cosmos," *Astronomy and Geophysics* 46, no. 5 (2005): 526-529.
[64] See P. de Bernardis et al, "Images of the Early Universe from the BOOMERanG experiment", CP586, in *Proceedings of Relativistic Astrophysics, 20th Texas Symposium*, edited by J.C. Wheeler and H. Martel (American Institute of Physics, 2001): 157-171.
[65] In Glaisher, *Travels in the Air*, 148.
[66] Dyson, *The Tone of Our Times*, 2.
[67] See Parikka, *A Geology of Media*.
[68] Sasha Engelmann, "More-than-human affinitive listening," *Dialogues in Human Geography* 5, no. 1 (2015): 76-79.

[69] See Jol Thomson and S. Engelmann (forthcoming) "Intra-acting with the IceCube Neutrino Observatory or how the technosphere may come to matter," *Anthropocene Review*. See also Thomson and Engelmann, "TIANHE ≋ 天河**:** Parables of the Celestial River", in *The Aerocene Newspaper*, a publication accompanying Tomás Saraceno's Aerocene Installation at the Grand Palais, Paris, December 2015. As Thomson and Englemann demonstrate, the detection of neutrinos is an important example of this kind of terrestrial sensing. See Y Suzuki and K Inoue, "Kamioka Underground Observatories," *The European Physical Journal Plus* 127 (2012): 111-119.

[70] For an account of this kind of field recording, see Michael Gallagher, "Field Recording and the Sounding of Spaces," *Environment and Planning D: Society and Space* 33 (2015): 560-576.

[71] John Durham Peters, *The Marvelous Clouds: Towards A Philosophy of Elemental Media* (Chicago: University of Chicago Press, 2015).

Withdrawing from Atmosphere:
An Ontology of Air Partitioning and Affective Engineering

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"Air was new, Air was strong, Air would bear her up. She knew now.
She was rooted in the world but the world was rooted in Air."

Geoff Ryman, *Air*, 2006

Abstract

The main objective of this text is to warn against atmospherics. However comfortable it might appear, an atmosphere is politically suspicious because it numbs a body into an affective embrace of stability and permanence. It becomes doubly suspicious because a body *desires* to be part of the atmosphere. For this reason, I rethink both affect and atmosphere ontologically rather than phenomenologically. I argue that an atmosphere is engineered by subsuming individual affects to what I call, following Sloterdijk, an atmospheric glasshouse. I suggest that this happens in four steps: a distinction between inside and outside through partitioning; inclusion of the outside inside; illusion of synthesis; and dissimulation. In order to do this, I begin with air as the elemental paradox of ontological continuum and rupture. I carry on with the passage from air to atmosphere while retaining the discourse around continuum and rupture. Finally, I indicate a way of rupturing the atmospheric continuum through the ontological movement of withdrawal from the atmosphere. The ultimate goal of the article is to sketch a problematic of atmospherics that puts together without synthesising an elemental ontology of continuum and rupture.

1. Welcome to your Glasshouse

In Geoff Ryman's novel,[1] air is a necessity that extends to more than just the living. It circulates between human and animal bodies, technology, knitted objects, freshly prepared food, the dead, even a whole village high in an imaginary Asian highland, in which the novel takes place. The world is rooted in this air – but this is no ordinary air. This Air (with capital A) transcends the world's skin in gasping breaths, connecting while isolating, pumping information, dead bodies, new commodities, capitalist ventures, temporal jolts and odd weather phenomena. This air is atmospherically engineered to facilitate consumerism, marketing, project

[*] I would like to thank Amy Kulper for the initial encouragement on atmospherics, as well as the two anonymous reviewers for their useful and knowledgeable comments.
[1] Ryman (2006)

management, design techniques – all that in an isolated village with hardly any electricity or telephones.

This air is found inside, an in-built internet-type databank that can be invoked through bodily functions. Hesitantly, some inhabitants learn to manage it, inevitably leaving the others behind. This air partitions while being partitioned. It is the air of an immense glasshouse. It *can* be shared, indeed it is engineered to be shared. But only in a prefabricated way, seemingly rooted in the desire of its participating bodies, while however eliminating all need for alternatives. Is this a waft of freedom? Or maybe the putrefaction of claustrophobia? You need to be breathing the same air in order to be part of us. You know of no other air. You desire the only air you know. This air has become an institutional affect.

It is imperative not to forget this kind of air, despite temptations to the opposite. Marin Nieuwenhuis calls this "unregistered air",[3] namely the kind of air inhaled without critical reflection, atmospherically offered as the only alternative. This air, polluted and gassed, or rationed and reserved for specific bodies, or indeed readily perfumed and seductive, is increasingly becoming our political, legal, architectural, cultural atmosphere. We are still rooted in air; but this air is now partitioned, engineered, conditioned, atmospherically contained, affectively directed, ontologically restricted. This air no longer moves freely between inside and outside, between breather and world; rather, it must negotiate various material and symbolic partitionings. Even this inside/outside is dissimulated to resemble something else, something ajar in the face of brutal closure.

From air to atmosphere, the partitioning is inevitable and its political impact vast. In its enclosure, an atmosphere directs bodies and their airborne affects in politically specific ways and for politically specific purposes. Of course, being an affective event,[4] an atmosphere is volatile and its control necessitates several subterfuges. But the greatest coup of an atmosphere is that it generates the very affects that desire its continuation: affects conscripted to the service of the atmosphere. Welcome to your glasshouse.

This means that the register must change. The usual phenomenological approach to atmospherics feeds into the very affects that perpetuate the atmosphere.[5] We need a distance from phenomenology. However difficult this might be,[6] it is a political responsibility: an atmosphere must be ruptured and its co-optation exposed. This can only happen, I argue, through an ontological approach that shows how an atmosphere directs individual and collective phenomenologies towards a specific horizon.

The main objective of this text is to warn against atmospherics. However comfortable, an atmosphere is politically and legally suspicious because it numbs a

[3] Nieuwenhuis (2015b) 92
[4] See Anderson (2009) and Thrift (2008)
[5] See however Ihde (2009), Bogost (2012), Spinney (2015).
[6] See Philippopoulos-Mihalopoulos (2011); also Roelvink and Zolcos (2014) and the whole special issue.

body (via the body's own desire) into an affective embrace of stability and permanence. Even so, I reserve a positive role for atmospherics. My ambivalence is manifest in the ethical ambiguity with which I employ concepts such as continuum and rupture, partition, inside and outside and so on. My purpose, therefore, is not to point to ethically problematic atmospheres,[7] or to distinguish between positive and negative atmospheres,[8] but to expose the ontology of atmospheric engineering. I am also interested in retaining the ambiguity of atmosphere as both a meteorological and an affective event.[9] For this reason, and this is the other objective of this text, I rethink atmospheric affects institutionally rather than subjectively. I argue that an atmosphere is engineered by subsuming individual affects to what I call, following Sloterdijk, an atmospheric glasshouse. The final objective of the text is to indicate a way of rupturing the atmospheric continuum through the ontological movement of withdrawal, itself not a passive gesture but a revolutionary movement of removing oneself from the atmosphere.

In what follows, I begin with air and perform the passage into atmosphere, while in section three, I lay out my objections to phenomenology. In section four, I look at the way affects become engineered in specific atmospheric ways and in section five, I address the main steps of the engineering process. In section six, I suggest a way out of atmospherics, based on a strategically employed understanding of ontological withdrawal, and in the final section I describe a withdrawal into air. The text is structured around an ontological paradox of continuum and rupture, according to which all bodies are part of the same ontological surface, while at the same time withdrawing from each other. I employ the theories of Peter Sloterdijk, Niklas Luhmann, Reza Negarestani, new materialisms, Deleuzian ontology and others, while also referring to the art practice of Tomàs Saraceno, an international artist who has worked both with the expanded aspects of air and its enclosures into atmospherics through his constructions that trap air while allowing its permeability. The ultimate goal of the article is to sketch a problematic of atmospherics that puts together without synthesising an elemental ontology of continuum and rupture.

2. From Air to Atmosphere

Air poses a multiplicity of challenges. As a rule, air is boundless. It is not easily contained for either scientific or theoretical scrutiny. Unlike solids or liquids, air partitioning requires significant technological investment both for the initial separation and importantly for its maintenance. On the other hand, air is hard to perceive. While weather phenomena, such as wind or fog,[10] and airborne smells or coloured gases briefly reminds us of air, the majority of times, as Luce Irigaray has shown, we forget air.[11]

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[7] see for example Borch (2011) and (2012)
[8] See, however, Philippopoulos-Mihalopoulos (2015)
[9] McCormack (2008)
[10] Martin (2011)
[11] Irigaray (1983)

Air is often understood as a void. Timothy Choy finds that "air is left to drift…neither theorized nor examined, taken simply as solidity's lack."[12] This could of course be, Choy continues, because "there is no 'air' in itself. Air functions instead as a heuristic with which to encompass many atmospheric experiences."[13] It is in that sense that Steven Connor describes air as "pure mediation."[14] For my purposes, *air is a conduit that mediates between phenomenological self and atmosphere*, or indeed the passage between phenomenology and ontology. The perception and apperception of air is a question of oblique manifestations that tickle one's phenomenological antennas. For this to happen, the air must be moved, coloured or lit in a way that makes it phenomenologically vibrant within the sensorially controlled circle of one's perception. In other words, air must be phenomenologically partitioned in order to be apperceived. Even early experiments on the nature of air involved a glass jar in which air (and usually some other thing) were trapped and at the same time opened to the scientific gaze. Through his glass tube filled with mercury, Evangelista Torricelli managed in the 1640s to show that the air is heavy, and that it forcefully pushes in all directions.[15] Thanks to further partitioning, we know that air bounces, vibrates and transmits.[16] Building on existing air partitioning, in 1859 John Tyndall constructed the first ever "mini-atmosphere", an intricate Victorian glass model, complete with controlled heat and light sources.[17] Air partitioning does not only take place for the purposes of scientific experiments. It is something that occurs regularly, unthinkingly, naturally. Air has always been both a physical and a moral issue, as Peter Adey points out.[18] It is split in social tiers according to geography, financial security, aesthetics and so on. The more we partition air, the more we discover its elusiveness. In doing so, we become aware of this rather peculiar fact: the air is elusive *because* of its partitioning. The fresh air up on the hilltops is as elusive as the miasmic air down the urban underbelly: the affluent residents of the suburbs are not better placed to capture the air than the environmentally aggrieved urban poor. They are both captured by the atmospherics engineered with them and by them. Yet, the other side of air is often tantalisingly breathed in through the partition left ajar. The air, as element, remains elusive.

So what is the elemental nature of air?[19] On the one hand, air is full of opportunities, a vast openness,[20] ready to be breathed in with future, available to be folded in the present, amenable to mnemonic bottling of the past: air as one infinite *continuum*. This aspect of the air has been apparent from very early on, from the first Greek philosophers. A fragment by Anaximenes of Miletus, known for elevating air to the principal originary element, reads: "since we come into being by an efflux from this

[12] Choy (2011 page 145)
[13] Choy (2011, page 145)
[14] Connor (2010)
[15] See Walker (2007, page 15*ff*)
[16] See Adey (2014)
[17] Walker (2007, page 90)
[18] Adey (2015)
[19] Adey (2015). See Engelman's (2015) and McCormack's responses on the challenge (same issue), which go beyond the human.
[20] Irigaray (1983)

(*air*), it is bound to be both non-limited and rich so that it never fails."[21] Air as always reliable, unlimited, and rich with opportunities. In its ideal political dimension, Marin Nieuwenhuis finds that "the air is not divisible on the basis of a territorial logic. The air's wholesome and ever-continuing body constitutes a politics that is radically democratic and equal."[22] But there is another side to air, which has opened up to scrutiny only after the publication of works by Sloterdijk and others[23] on the political and military use of air. No longer unlimited, air is now understood as *rupture*: air as control, manipulation, compulsive desiring, communal identities and spatial partitioning. Air traverses freely everything we know and care for; yet it is also put in the service of ruptured atmospherics. Remarkably, the one side does not annul the other. Rather, aerial continuum and rupture are to be approached simultaneously, respecting their paradox.

This is the elemental nature of air: *the paradox of continuum and rupture, inclusion and exclusion, openness and closure*. Air is the principal geological, political, legal, architectural, geographical and cultural paradox that crosses animate and inanimate bodies and the spaces between them. I think of air here in its material manifestation as the sum of atmospheric gases, but also as the informational, emotional and sensorial continuum in which affects circulate. This is not metaphorical air but *elemental* air. In that respect, I take up the challenge issued by by Peter Adey on what it means to be elemental.[24] While I wholeheartedly agree and even polemically argue (below) that phenomenology is not the way to deal with the elemental, I am less hesitant than Adey in foregoing the potentially romanticising dealings of air.[25] Focussing rather on its affectively engineered aspect is the only way in which the elemental can be understood ontologically: *it is through its being engineered that the elemental makes itself ontologically relevant*.[26] As I show below, the limits of this is the ontological withdrawal of all bodies, including elemental ones. I do not consider the elemental a transcendence but an immanent materiality, put in use depending on the assemblage in which it emerges. The difficulty with the elemental is its paradoxical nature that defies fault-proof interventions. Even so, because of its nature, the control of the elemental has far-reaching repercussions in all other domains of the animate and the inanimate. On account of its ubiquity as both physical expanse and sociopolitical factor, air is regularly delegated to the position of a hanging apple ready to be harvested. Air captured is knowledge opened up. Apple in hand, and the garden blossoms to the etiolated air of the outside. But then, no longer is there garden, and the earth becomes one shadeless surface. Air remains always one but this one has all the allure of Rem Koolhaas's *Junkspace*[27] or Peter Sloterdijk's *Glasshouse*,[28] neither of which desirable places to live, should one had

[21] Anaximenes, fragment 3 (1948, page 19)
[22] Nieuwenhuis (2015a)
[23] See e.g., Sloterdijk (2011), Connor (2010), Adey (2010), Whitehead (2009), Neocleous (2013), Nieuwenhuis (2013)
[24] Adey (2015)
[25] See Steinberg's (2015) critique of Adey.
[26] Hence the political approach in Nieuwenhuis (2015a) and Feigenbaum and Kanngieser (2015).
[27] Koolhaas (2002)
[28] Sloterdijk (2013)

the freedom to choose. Yet, we all live in them, and we all think we have chosen freely.

Air is the phenomenological mediator for atmosphere. If air is elusive, atmosphere is more so. This is because atmosphere takes the aerial paradox and encloses it on one side. While air is both continuum and rupture, atmosphere is one large rupture containing both continuum and rupture. An atmosphere contains the aerial paradox reinscribed, safely trimmed, neatly enclosed. Louis Dumont has famously called this *englobement du contraire*, the encompassing of the opposite.[29] Atmosphere is an infinite, continuous lab ("the laboratory has extended its walls to the whole planet"[30]) in which affects are directed in prefabricated ways, and where bodies are wilfully placed in a position of belonging. Everything is affectively connected to everything else through their desire to belong to the atmospheric continuum; yet, at the same time, everything withdraws in this atmosphere, succumbing to its ruptures. One finds both continuum and rupture in the atmosphere, but no longer as the elemental paradox of the air: the paradox has been tamed, the air has been captured, the atmosphere has emerged.

The overarching atmospheric rupture relies on the mechanical (human and non-human, thus geological, climatological, discursive, territorial and so on) partitioning of air. On a lab level, creating an observable atmosphere is difficult because of the complexity of physical conditions to be reproduced. In its geological form, the earth's atmosphere is the ultimate aerial partitioning, separating air from non-air. Within that partitioning, everything is held together, attracted to each other in the name of the dark sky above. Atmosphere is a force of attraction. It relies on gravity to hold onto even the lighter gases necessary for atmospheric emergence. The connection between gravity and atmosphere is not unidirectional but cyclical: via gravity, atmosphere attracts its own elements, self-perpetuating its fine aerial balance, allowing the emergence of James Lovelock's Gaia Theory, according to which the earth's consisting bodies produce and maintain Gaia as an emergence that includes all these bodies yet exceeds them.[31] Atmospheric self-perpetuation, however, is not strictly speaking independence. It relies on a conditioned relation with its outside. Atmosphere consumes whatever tries to enter it from the surrounding environment. It flattens it and makes it its plaything: an object turning into fire turning into air. Like the Homeric Sirens, atmosphere seduces and cannibalises the intruders, converting them into its own elemental aerial nature. Architectural atmospheres are similarly all-absorbing and sensorially totalising, as Peter Zumthor shows in his influential book *Atmospheres* - a blueprint of how to create an attractive atmosphere.[32] Once inside, the outside ceases to exist. It becomes sky, phenomenology, filtered reality. Its ontology becomes de-ontologised, mediated by atmospheric self-perpetuation. Everything splays into the individual atmospheric bodies that desire things to remain just so. The aerial continuum is now tightly inside.

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[29] Dumont (1967, page 397)
[30] Latour (2003, page 3)
[31] Lovelock (1982)
[32] Zumthor (2012)

3. The Limits of Phenomenology

From air to atmosphere, the register changes. While air's presence relies on phenomenological apperception,[33] atmospherics demand a different strategy that ushers the political into the elemental. Peter Adey correctly finds that "the phenomenological is often told apart from economic, legal and class struggles, so obviously imbibed by aesthetic sense and meaning."[34] The very tool of apperception, namely partitioning as a form of Husserlian bracketing (or *epoche*), turns against its own function and allows the aerial elemental paradox to escape, like badly bottled gas. We cannot apperceive an atmosphere because we are always already in it. Instead of liberating, phenomenological bracketing seduces us in atmospheric "attunements" as Kathleen Stewart put it,[35] that still, however, begin from the difference between subject and object, rely on a human presence, and aim at the worlding of things, namely their unfolding before our senses. Even the ultimate Husserlian cry "to the 'things-themselves'"[36] falls flat: if atmospherics shows us one thing, it is that *there is no difference between self and environment, body and its atmospherics, human and things*.[37] Atmospherics pushes us decidedly away from the phenomenological opening between consciousness and thing, however much intentionality (Husserl), ontotheology (Heidegger) or even chiasmatic flesh (Merleau-Ponty) have tried to bridge it. We are all deep in atmosphere – an unfamiliar, elusive atmosphere where the human is replaced by the posthuman, the animal, the technological, the monstrous.

What is more, atmosphere *precedes the bodies of its emergence*. The velocity of atmosphere is higher than that of its participating bodies. An atmosphere emerges in what Nigel Thrift calls "the country of the half-second delay"[38] – the time consciousness needs to catch up with reality, which is often much longer.[39] Although intimately relying on these bodies (there can be no atmosphere without planet, gravity, a variety of gases, inanimate and animate things), atmosphere precedes and exceeds them. It is not just the total sum of its bodies of emergence but a thing of differential velocity, an emergence. According to its less traditional etymological trajectory, sphere (in Greek *σφαίρα*, 'sfaira') stands for *missile* or *bullet*. This atmobullet shakes with a pulsating velocity, a continuous yet imperceptible movement, a static yet vertiginous drive, quickened by its conative[40] desire to perpetuate itself.

Another reason for which atmosphere remains outside individual or even collective consciousness is the difficulty of apprehending an atmosphere in its totality without

[33] Although see Ingold's (2006) ontology of air's animate agency.
[34] Adey (2015, page 59)
[35] Stewart (2011)
[36] Husserl (2001, page 168)
[37] Brennan (2004)
[38] Thrift (2008, page 186)
[39] McCraty, Atkinson and Bradley (2004, pages 133-143)
[40] Spinoza (2000) denoting the will of a body to carry on becoming. Also Bennett (2010),

being sucked into the very atmosphere's phenomenologising techniques. Phenomenological apprehension leaves out a large chunk of what an atmosphere is, namely a supra-corporeal emergence that does not rely on consciousness, individual apperception or subjectivity – or, as Derek McCormack's puts it, "a set of dynamic and kinetic affects, where affect is the pre-individual intensity of relation between bodies."[41] Phenomenologically, an atmosphere is mood, feeling, sensorial response. It is properly speaking, affective. But *in its ontology, an atmosphere encompasses its phenomenological emanations in a glasshouse that elevates affect to an institutional normativity*. Affects are directed in the service of atmospheric perpetuation.

In sum, ontology lies at the bottom of an ocean of airborne phenomenology, to paraphrase Torricelli's famous sentence: ("We live submerged at the bottom of an ocean of air."[42]) We humans are more comfortable in our phenomenological ocean, deliberately ignoring the non-human and the inanimate.[43] Atmosphere relies on animate beings (and not just humans), including the hydrogen-feeding bacteria before oxygen made it appearance on earth. But no animate being on its own can generate an atmosphere. The earth's atmosphere is the outcome of a precise gas cocktail, along with dust and pieces of rock, collapsing and coalescing into the planet we know and inhabit. Nor is atmosphere only on the surface of the earth. Gases have been trapped between the pieces of dust and rock, themselves constituting the core of the earth. These facts demand a different understanding of the role of the inanimate in the emergence of atmosphere.[44] Levi Bryant puts it clearly: "there is no reason to suppose that a phenomenological analysis can tell us about the being of beings or machines, as phenomenological analysis only tells us how we encounter beings, not how beings in and of themselves are."[45] An atmosphere relies on animate and inanimate bodies to remain complicit with it for as long as the future and as far as the horizon. The phenomenological time becomes one endless *now*, the phenomenological space one infinite *here*.

It is, therefore, surprising that the relevant literature insists on phenomenology.[46] Take for example Gernot Böhme's definition of atmosphere: "the common reality of the perceiver and the perceived."[47] In his attempt to move beyond architectural ocularcentrism, Böhme includes moods and emotions, but his atmospherics remains firmly phenomenological: "seeing is all about distance. Not immersion. The sense of being in something is 'mood'. By feeling our own presence, we feel the space. We feel its atmosphere."[48] This position is problematic in many respects, and not least in that it presupposes a (human) subject and an object, thus resuscitating (by attempting to bridge) the Cartesian distinction phenomenology has been trying to distance itself from, as well as significantly the various racial, gender, and sexual

[41] McCormack (2008, page 418)
[42] see Walker (2007, page 18)
[43] See however McCormack (2008), Adey (2010)
[44] Walker (2007)
[45] see Bryant (2014, page 113)
[46] see Anderson (2009) and Fischer (2007)
[47] Böhme (1995, page 34)
[48] Böhme (2005, page 402)

perspectives that have the potential of radically affecting the atmosphere.[49] Böhme's 'betweeness' of atmosphere largely follows Schmitz's argument against the private nature of emotions and indeed the revival of the Homeric concept of emotions originating in the space surrounding the body.[50] As Schmitz writes in a previous work, "space flows along with us."[51] An atmosphere does not need utterances or even other human presences in order to emerge, Schmitz correctly argues. But then, Schmitz continues,[52] the affected body is entirely taken over by the atmosphere, becomes totally embedded in it. If, however, this were to happen, then an atmosphere would never emerge. An atmosphere relies on its bodies, and these bodies must remain part of the atmosphere on their own accord. *Bodies need to desire the atmosphere in order for the latter to carry on.* Ben Anderson's suggestion of atmospheres as "a class of experience that occurs before and alongside the formation of subjectivity, across human an non-human materialities, and in between subject and object distinctions"[53] redresses several important problems, but still puts forth an understanding of atmosphere as an experience, that is furthermore taking place in-between categories that is imperative to overcome. But neither subject/object distinctions nor dialectic in-betweens have helped much so far, especially at this time of hyperobjects which, as Timothy Morton has pointed out, are so large and immanently expandable that are never fully present, yet manage to engulf everyone.[54]

To sum up before moving on: it is politically important to understand atmospherics ontologically. There is a significant difference between a phenomenologically apperceived atmosphere (which can be a question of mood, taste, personal disposition and so on) and an ontologically approached one. Although connected to bodies and their affects, an ontological atmosphere does not engage with the distinction subject/object, but with the indistinguishability between the two. This also means that an atmosphere is a posthuman emergence, not centred on human experiences or connections but rhizomatically spread across the (human and nonhuman) bodies of its emergence. An ontological atmosphere is temporally precedent, because it moves faster than its bodies of emergence. Finally, an ontological atmosphere is always supraconscious, and guides its individual bodies in such a way that the latter remain in the service of the atmosphere.

4. Institutionalising Affects

Atmosphere is held together through the affects of the bodies of its emergence. Let me first clarify that bodies here must be considered in the Spinozan/Deleuzian sense, according to which "a body can be anything: it can be an animal, a body of

[49] see also Löw (2011)
[50] Schmitz (1995, page 292)
[51] Schmitz (1967, page 3)
[52] Schmitz (1995)
[53] Anderson (2009, page 78)
[54] see Morton (2013)

sounds, a mind or idea; it can be a linguistic corpus, a social body, a collectivity."[55] These bodies are held together through affects that exceed the bodies of their materialisation. Michel Serres's enigmatic "the body exceeds the body"[56] points to how affects are both embodied and excessive. Brian Massumi defines affects as "virtual synesthetic perspectives anchored in (functionally limited by) the actually existing, particular things that embody them".[57] An affect can never be fully captured and assimilated – it is both plural ('synesthetic') and future-tending ('virtual'). Massumi points to the affect's inability to be fully captured, the "escape of affect"[58]. Although firmly rooted in the body, the affect protends to its virtual becoming. This excess, collectively yet autonomously, is the atmosphere, always coming earlier than consciousness and at the same time capturing the future. Atmosphere exceeds its bodies towards a collectivity that cannot be fully described or indeed prescribed.

An overview of what an affect is lies beyond the scope of this article. I have previously argued that the affective discourse must reconsider the usual emotional, sensorial and discursive exclusions.[59] The challenge is multiple: first, to understand affect as an indistinguishable totality of the above elements; second, to take affects, not as phenomenological, human-originating qualities but as posthuman, acentral, excessive attributes of an atmosphere whose ontological appearance is institutionalised. Thus, affect is posthuman in the sense that it neither originates nor ends necessarily in humans; acentral, in that it floats about rather than causally originating in one source; and excessive of its body of origin, fully given to the way the aerial continuum. This is the groundwork of an ontological understanding of affective atmospheres.

Affects become collective through transmission. In her seminal psychoanalytical work, Teresa Brennan has shown how affects are transmitted from bodies and spaces to other bodies and spaces.[60] The same theoretical point is made by Sloterdijk, referring specifically to Gabriel Tarde's concept of imitation.[61] In *Laws of Imitation*, Tarde analyses the charismatic leader and how such a presence can kick-start a wave of imitative somnambulism: "society is imitation and imitation is a kind of somnambulism."[62] In the era of governmentality, however, a leader is internalised in each body and in the spaces between those bodies that engage in a self-policing, but most importantly, desire-creating frenzy. This is what Foucault means when he notes "the emergence, or rather the invention, of a new mechanism of power possessed of highly specific procedural techniques...which is also, I believe, absolutely incompatible with the relations of sovereignty.... It presupposes a tightly knit grid of material coercions rather than the physical existence of a sovereign."[63]

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[55] Deleuze (1988, page 127)
[56] Serres (2008, page 307)
[57] Massumi (2002, page 35)
[58] Ibid.
[59] Philippopoulos-Mihalopoulos (2013)
[60] Brennan (2004, page 170). See also Mitchell (2011)
[61] Sloterdijk, (2004), and Tarde (1903).
[62] Tarde (1903, page 81)
[63] Foucault (2003, pages 35-36)

Shared affects, embodied yet exceeding their bodies, enable an atmosphere to emerge. *Atmosphere is the excess of affect that keeps bodies together; and what emerges when bodies are held together by, though and against each other*.

The turning point of an engineered atmosphere is the specific direction it gives to affects. For, although an affect is excessive, acentral and posthuman, it is regularly manipulated or at least smoothed in an institutionalised direction. In *Libidinal Economy,* Jean-François Lyotard describes affects as the libidinal intensities that allow a system to direct desire.[64] In that sense, affects are regularly exploited and channelled to serve consumerist needs, capitalist abstractions, legal obedience and political placation. In order to be better controlled, they are partitioned in discreet air-conditioned spaces: warm and cosy, cool and bracing, balmy and luxurious, polluted and degraded. Just as there is no escape from air, there is no escape from affective air-conditioning: "Air conditioning is destiny."[65] This air-conditioned partitioning where affects circulate in predetermined ways, is an engineered atmosphere. An engineered atmosphere "knows all your emotions, all your desires. It is the interior of Big Brother's belly. It pre-empts people's sensations. It comes with a sound track, smell, captions; it blatantly proclaims how it wants to be read: rich, stunning, cool, huge, abstract, minimal, historical."[66] This is the point of Sloterdijk's analysis of the *World Interior of Capital* as "a climatized luxury shell in which there would be an eternal spring of consensus",[67] which finds its most prominent form in the Grand Installation of the glasshouse of capitalism, that "interior-creating violence of contemporary traffic and communication media."[68] By the same token, an atmosphere is not only calm and luxury. It can be equally effectively engineered as a conflictual, violent or unpleasant atmosphere, in which a body would feel comfortable. Odd as it might be to talk about comfort in a violent or conflictual atmosphere,[69] comfort denotes belonging, and belonging exists across shopping malls and political battles alike. Whether it is engineering on a global scale, or localised engineering of a particular shopping mall, the affects employed, exploited and atmospherically institutionalised are the same.

In what follows I trace the main steps to engineering an atmosphere. Suffice to say, however, that it is not easy to produce an engineered atmosphere. To foreshadow the below, I would like to argue that *an atmosphere is successfully engineered when it manages to rupture the affective continuum with the outside, while at the same time reproducing it inside and presenting it as the only atmosphere possible*. This is the geology of atmosphere: outside there is no air. Here is the only possible place to be. Here, one has everything one desires: we are surrounded by the "climatological erotics" of air-conditioning, as Mark Dorian puts it,[70] but this time as a self-loving, solipsistic, fully self-sufficient atmoporn.

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[64] Lyotard (1993)
[65] Sloterdijk (2014, page 964)
[66] Koolhaas (2002, page 183)
[67] Sloterdijk (2013, page 170)
[68] Sloterdijk (2013, page 198)
[69] See Lambert (2013, page 46), and Philippopoulos-Mihalopoulos (2015) on the problematic of comfort.
[70] Dorian (2012, page 29)

5. Engineering an Atmosphere

An ontology of atmospherics requires its own engineering. Tomàs Saraceno's art installations offer just that. They consist of baubles made of glass or plastic filled with air and occasionally some other organic or inorganic material. Air is folded in the transparent wombs resembling miniature glasshouses. The partition is absolute, creating a hermetic atmosphere in each glasshouse. In the engineering of these glasshouses, the atmospheric ontology emerges. We are not in it, yet we are part of the installation. We can see it from a distance, yet we are interrupted by its transparency. We can observe the two sides of the air: boundless and bound, continuous and ruptured. We can observe the way atmosphere and conditions bounds the air inside. We can also observe how the affective continuum with the outside is achieved. Indeed, we can observe this very invisible of visibilities: the boundary. Saraceno's glass separates while allowing immersion. Immersion folds inside, separation leaks out: ontology emerges.

Saraceno's constructions oblige us not to forget the air. The air is constantly present because it is continuously interrupted: glass partitions that allow seeing-through without transmitting the air. Inside, the air is enough for the encased bodies (plants, earth, water and other matter) to fulfil their function. *There is no need for more air*. The air is perfectly conditioned, it takes spherical form, becomes liquid perspiration, fills with the odour of the plastic, and gets hued by the light around it.[71] Saraceno's work embodies the ontology of a ruptured continuum. Each bubble is the perfect atmosphere of rupture (safety, isolation, immunity, independence, belonging) *and* continuum (the air outside remains always remembered and always present because of the transparency of the partition). The atmosphere has been engineered as a grand rupture that includes the ontology of air in its paradox as continuum and rupture. However, only the rupture is real. The continuum is an illusion allowed by transparency.

Temporally, an atmosphere encapsulates the past and the future in the perfect *now*. Referring to glasshouses, Sloterdijk writes: "such edifices took into account that…the random uprooting of organisms to plant them elsewhere could only occur if the climatic conditions were transposed along with them."[72] Glasshouses, in other words, rupture the air while encouraging an encapsulated history of provenance and a situated capture of future. The uprooting involved in the transplantation finds its equivalent in the construction of the ancient Greek city, which for Sloterdijk "was a greenhouse for people who agreed to be uprooted."[73] The key word is "agreed": a contagious desire to agree that speaks from within each individual body, affectively directing it to stay put. This is what Mark Whitehead calls "the self-regulating atmospheric subject", subjected to an atmospheric governmentality of displaced

[71] Sloterdijk (2004, page 255) calls this "connected isolation". See also Latour (2011) on Saraceno.
[72] Sloterdijk (2005, page 944)
[73] Sloterdijk (2005, page 944)

responsibility from the state to the individual herself, and packaged as empowering subject-positions.[74]

The above allows us to trace the way an atmosphere is engineered. The first step is the distinction between inside and outside,[75] where the outside is marked as a negative space: think of gated communities spatial organisation on the basis of exclusion of the outside. Add to this the second step: the outside is *included* inside. The predominant affect of an engineered atmosphere (of a gated community, of a club with strict entry requirements, of fortress Europe, of capitalism and so on) is one of 'comfort': we belong. We have all we need right here. An engineered atmosphere is "an enclosure so spacious that one would never have to leave it."[76] Nor could they leave it easily, even if they wanted to. Where would they go anyway? "It is always interior, so extensive that you rarely perceive limits" writes Koolhaas on his own precipitous description of the atmospheric as junkspace.[77]

The third step of an engineered atmosphere is an illusion of synthesis. This is what Reza Negarestani in his influential hybrid *Cyclonopedia* means when he writes that the objective of any air enclosure is "to distil all cosmic processes into one unified body which is cyclically infinite yet functionally restrictive (everything must be unified). Such an environment or sphere functions as a cyclic or a spherical shape with an inner limit and an outer boundlessness."[78] This is the illusion of synthesis that engineered atmospheres emulate: both continuum and rupture are already included within. The air is captured in its elemental form – an anthropocentric triumph: we have captured the elemental nature of the air! We sealed it inside while allowing it to roam wild. In both cases, the story goes, the air is ready to serve us. A win-win situation. "There are no walls, only partitions, shimmering membranes."[79] So stay inside and enjoy the best of all worlds. We are protected by the air inside, a round present vibrating with vaporous promises: we are protected by *atmosphere*. Negarestani again: "Air as a manifest refinement is a vision-machine through which the world *looks safe*, that is to say, already consolidated, having been forced to take the path of unification and purity."[80]

But think of Saraceno's glasshouses again: their immunity is only impressionistic. The synthesis of continuum and rupture inside is illusionary. The only thing an atmosphere does is to rupture, disaggregate and isolate: "it creates communities not out of shared interest or free association, but out of identical statistics and unavoidable demographics, an opportunistic weave of vested interests."[81] An atmosphere cuts through the ontology of elements, isolating their paradoxical sides, not allowing them to connect. But it does this on a bed of continuum, agreement,

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[74] Whitehead (2009, page 225)
[75] Luhmann's (2012 and 2013) most fundamental distinction, that significantly influenced Sloterdijk.
[76] Sloterdijk (2013, page 175)
[77] Koolhaas (2002, page 175)
[78] Negarestani (2008, page 102)
[79] Koolhaas (2002, page 176)
[80] Negarestani (2008, pages 102-3, emphasis added)
[81] Koolhaas (2002, page 183)

desire. This is the last step: an atmosphere must dissimulate itself as pure emergence and never show itself to be an engineered feat, for otherwise the illusion will not be complete and resistance to it will be cropping up at an uncontrollable rate.[82] Thus, an engineered atmosphere dissimulates, indeed ruptures, its engineered provenance and volatility. Shopping malls are built so that one has to walk slowly, cannot find easily the way out, and is bombarded by constant shopping 'needs'; add to this the fact that one cannot stage a protest or bask or run or wear a hood or do anything other than what is prescribed; and then add what the customers expect from a shopping mall and how any untoward gesture is seen suspiciously. This is the perfectly engineered atmosphere: when the very bodies police themselves, even in absence of obvious legal norms. Dissimulation means: no one has engineered the atmosphere, no one has organised the participating bodies to generate it. Nothing has instilled the bodies with the desire to regulate themselves in accordance to the atmospheric bubble.

6. Withdrawal from Atmosphere

The above mechanisms are not meant to operate as a blueprint on how to engineer an atmosphere. Quite the contrary: my motivation is to warn against the seduction of atmospherics and the way they tend to numb the phenomenological body in a state of desire for carrying on being part of it. By looking into the engineered emergence of an atmospheric ontology, however, a critical rupture to the atmospheric continuum is inflicted, taking us backstage where the magic happens. Once aware of the atmospheric smoke and mirrors, one does not so easily succumb to it.

Ontology is of course not a panacea. Except for the issue of 'my ontology is better than yours',[103] for which only a radical epistemology might be the answer,[104] ontology is compromised by what it ultimately reveals: *that not everything is revealed*. There is always a part of a body that withdraws from being, folds inside, and remains unconnected. This is the ontological withdrawal as it reached us from Heidegger.[105] Its appeal, however, is also postphenomenological, since it intimately connects to the Deleuzian/Guattarian notion of excess, as its flipside.[106] They both move in a similar direction, away from connectivity and towards becoming minor and ontologically concealed. The difference is that whilst excess ontologically blinds with its diffused non-connectivity, withdrawal darkens in an inner fold of internal connection. Excessive or withdrawn non-connectivity characterises all bodies, however implicated in the continuum. A new theorisation generally responding to the name object-oriented ontology,[107] has taken a distance from the obsessive

[82] See McCormack (2008) for engineered and emergent atmospherics in terms of meteorology and affectivity, to which I add the strategy of dissimulation.
[103] Hubbard (2012)
[104] E.g., Luhmann (2012 and 2013)
[105] Heidegger (1978)
[106] Deleuze and Guattari (1986)
[107] Clough (2010), Harman, 2005), Bryant (2011), Morton (2013)

hyperconnectivity of theories such as ANT, and shows how ontological withdrawal is the shadow of networks. Thus, Levi Bryant writes: "withdrawal is not an accidental feature of objects arising from our lack of direct access to them, but a constitutive feature of all objects regardless of whether they relate to other objects."[108] Objects withdraw from each other, indeed "absolutely from every relation",[109] since they are neither reducible to the sum of their relations, nor however are they ever fully ontologically revealed. "We are always on the way to withdrawal",[110] Negarestani writes. Withdrawal works as one side of the ontological paradox, the other being the possibility of carrying on being unified.[111] Just as in the case of the elemental side of air, ontology is a paradox between continuum and rupture, revelation and concealment, openness and closure.

The way described above however, ontological withdrawal lacks the political element of resistance to atmospherics. As a reality of all bodies, hardwired in every gesture and every desire, withdrawal can go either way. Cocooning in an atmosphere is a form of withdrawal, regularly exploited by atmospheric engineering in the form of illusions of belonging. To know when to withdraw from one's desire, however, is the real moment of withdrawal. I have been writing on withdrawal from the perspective of law and justice, arguing that justice is a gesture of withdrawal from the situation in which one is politically and legally forced.[112] In that vein, I propose that ontological withdrawal can be a strategic gesture, politically organised to help escape an atmosphere. In other words, I am keen on adding the political to the ontological, thinking of withdrawal as a way out from the atmospherics of desire.

This is far from easy. If successful, an engineered atmosphere precludes any possibility of way-out, resistance or even reaction to it. An important factor in achieving this is the dissimulation of legal and political structures and the presentation of the particular atmospheric space as *anomic*, namely without law, or more specifically without the *need* for law. This does not mean that what is offered is illegal. On the contrary, it would be a space beyond the distinction legal/illegal: it is, finally, a *just* space. Or so is felt by the participating bodies. Through its various dissimulations, an atmosphere presents itself as a duration of theological enclosure, whether Edenic or heavenly. It is an end-destination, a divine equilibrium that has even managed to get rid of the divine presence all together: the law is no longer needed since every body has found its place. But there is a price to pay for living in a place where the potential of a conflict with the law is suppressed and replaced with a general atmosphere of *de facto* functionality. This loss of the normality of risk, difference and conflict directs affective desire in a particular way, and makes it imperative for these conditions to be maintained, whatever the political cost. This is indeed the perfect atmospherology: security is provided because it is desired, and it is desired because it is provided. Roberto Esposito writes: "as in all areas of contemporary social systems, neurotically haunted by a continuously growing need for security, this means that the risk from which the protection is meant to defend is

[108] Bryant, 2011: 32
[109] Harman, 2005: 76
[110] Negarestani (2008, page 50)
[111] Harman (2011)
[112] See for example Philippopouos-Mihalopoulos (2010)

actually created by the protection itself."[113] Atmosphere is often the result of dubious political, legal and architectural action, such as neighbourhood cleansing, legally encouraged ethnic homogeneity through immigration policies, walled communities, CCTV and so on. Security is a fragile, fully engineered atmosphere that relies on exclusion and purification, as well as intense conditioning of residents in order to actually desire this sort of non-legal, non-conflictual, seemingly safe atmosphere. What happens when atmospheres "place the individual in a circuit of feeling and response, rather than opposition to others" Clare Hemmings wonders, namely in an anomic, non-conflictual circuit with no apparent exodus?[114] Quite simply, the desire to find a way out is minimised, and completely overtaken by the desire to carry on business as usual.

How is then a body convinced to withdraw from an atmosphere? An ontological distance from atmospheric seduction is obviously pivotal, but how is this achieved? Paradoxically, what entraps, also offers a line of flight. One never knows exactly how the engineering will work out. It may or may not work according to plan. Sloterdijk refers to Dostoyevsky, who, even amidst his critical fascination with the glasshouse phenomenon, was convinced that "eternal peace in the crystal palace would mentally compromise the inhabitants."[115] But not just mentally. An atmosphere does not discriminate between human and nonhuman. Just as every body is summoned in the service of atmosphere, every body's failure is a potential atmospheric failure too: people get bored, things break, the weather changes, technology lets us down, governments fall, accidents happen, disasters hit. Affects become too excessive to be controlled, and when aggregated in the form of atmosphere, they change in volatile ways, even when established techniques of complexity reduction are followed.[116] At such points, an atmosphere changes, becomes-other. The conservative atmospheric urge is to continue in the business-as-usual mode and aim for homeostasis. However, at the point of becoming-other, an atmosphere becomes ontologically vibrant, and possibly phenomenologically apperceptible. Epistemologically speaking, it becomes accessible as rupture, or different atmosphere. This is the chance for a withdrawal from atmospherics: right when the crack between atmospheric becoming becomes vibrant, and the atmosphere is no longer able to contain and direct the excess of affect. Matt Finn describes it thus: "the apparent power to change or 'kill' the atmosphere can come with the same startling rapidity, where someone's mere bodily presence ruptures the collective interpersonal sensibilities."[117] In that sense, withdrawal can be conflictual and forceful, provided that the existing atmosphere has not already conscripted conflict in the service of the atmosphere. Or it can be a gesture of gliding opposition: find the cracks and ride them, surf on the atmospheric movement of engineered normativities, dwell on the here of atmospheric dissimulation.

A particular kind of courage is needed to leave behind one's bubble of comfort, however defined. Withdrawal might take advantage of cracks, but itself is a strategic

[113] Esposito (2011, page 141)
[114] Hemmings (2002) in the context of affect.
[115] Sloterdijk (2013, page 171)
[116] Sloterdijk (2005, page 948)
[117] Finn (2015, page 5)

movement, although perhaps without the full consciousness of a discerned objective. It is a movement away from an atmosphere with the aim of dismantling this atmosphere and reorienting the bodies within it to a different horizon: "the revolutionary knows that escape is revolutionary -*withdrawal, freaks*- provided one sweeps away the social cover on leaving, or causes a piece of the system to get lost in the shuffle. What matters is to break through the wall."[118] Deleuze and Guattari's reworking of Nietzsche's eternal return flesh out the force of withdrawal as a revolutionary movement, provided that the atmosphere is swept away by it. The (glass) wall must be broken, and its two sides ruptured: both the actual perpetuation of the atmosphere, and the perpetuation of the individual body's desire (indeed, there is no difference). The air, in its full elemental paradox, must be claimed. No longer the atmospherically conditioned air but an air fully given to the unresolved fight between continuum and rupture. *Withdrawal goes against one's own desire to remain put.*

Luckily, one is rarely alone. A mobilisation of collectivity is often a condition for the strategic rupture of withdrawal, even if not always in an obvious manner. It does not have to be a 'united front' or a worked-out agreement. It can be, and increasingly is, an emergence that lasts for as long as it does. It can be found in such symbolically and actually charged spaces such as the Palestinian Occupied Territories,[119] the atmospheric nationalism of Olympic games,[120] the London Riots in relation to surveillance atmospherics;[121] but also in small everyday acts of withdrawal from what the atmosphere dictates bodies to do. This is what Paul Celan's *Atemwende* captures: the rupturing of one's regular breathing rhythm, and the withdrawal from a common breathing pattern.[122] The moment one stops and reflects on the air and its imposed partitioning, is the under-breath that cracks the aerial domes of atmospheric oneness. Jane Bennett talks about that when she writes that "perhaps the ethical responsibility of an individual human now resides in one's response to the assemblages in which one finds oneself participating: Do I attempt to extricate myself from assemblages whose trajectory is likely to do harm?"[123] Less pronounced in Bennett's work is the gravitational pull of a promise of constancy, making withdrawal all the harder. This is not metaphorical language. In the epoch of the Anthropocene, where humanity's engineering affects the earth's atmosphere in geologically irreversible ways, the challenge is to withdraw from the illusion of human centrality, while retaining the ontological knowledge that the human is, by now, everywhere. This is the new responsibility of the human: to go against her own self-governing impetus.

7. Lighter than Air

[118] Deleuze and Guattari (1983, page 277)
[119] Lambert, 2011
[120] Closs Stephens, 2015
[121] Ellis, Tucker and Harper (2013)
[122] Nieuwenhuis (2015b), referring to Celan (1968)

[123] Bennett (2010, page 37)

Ultimately, the ontological occlusion remains: we do not know *how* bodies withdraw. An engineered atmosphere makes use of this occlusion by strategically converting it into a comfortable dissimulation, making bodies feel that they are both withdrawn *and* connected. This is the main difference between engineered and emerging atmospherics: while both cover the basic conative need of withdrawal, in the latter case the connection is only phenomenological. An atmosphere needs to keep bodies apart in order to control the way affects spread. The scale is now one of bubbles, as Sloterdijk has found in the first volume of his trilogy: each body is isolated in immunised conditions, separate from each other. For Sloterdijk, the connection is actual, in its turn giving rise to the societal *foam*.[124] But for the kind of atmospherics I talk here, the connection is purely impressionistic, facilitated by the translucence of the partition. An atmosphere apparently keeps bodies together, while in reality it keeps them apart.

The game must go on. Tomàs Saraceno's recent project, which is also his response to Bruno Latour's invitation to construct a monument to the Anthropocene, is a solar balloon.[125] Launched in Toulouse in October 2014, the balloon relies on the principle of lighter-than-air constructions that soar merely by virtue of their differential weight to the air around them. Of course, the balloon is filled with air whose lightness is continuously produced within the balloon's skin by means of solar heat. But the partition is only partly isolating the air; it actually allows the air to circulate freely between inside and outside, constructing a different understanding of inside which is not only contiguous with its outside but, significantly, refillable. This is neither an illusion, nor a dissimulation. It is an actual manifestation of how continuum and rupture can operate devoid of atmospherics. There is a shift of focus here, from glass closure to balloon opening. Of course, the opening is not so large that it would annul the enclosure, but enough to bring a different input in atmospherics. No longer an issue of isolation but of aerial withdrawal, the balloon withdraws from the earth while soaring up in the air. The balloon's manufacturing process is indicative: it is a collective effort from various people across the globe collaborating in providing the material and stitching it together. The balloon's withdrawal is hardly absolute, but its ontology opens up a different line of flight than the previous atmospheric configurations. It opens the path for what Ash Amin and Nigel Thrift have seen as the profoundly political responsibility of cultivating *alternative* affective connections.[126]

Here, withdrawal bears the news of an elemental rupture: there is a way out! One can go higher, can leave this atmosphere for a different one, can forge new affective connections. One can escape to what Tim Ingold has called *weather-world*, that zone of flows between earth and sky,[127] where one can finally live in the Open, the Outside. Or even the Aristotelian *aether*, the infinite zone that surrounds the air, away from atmospheric air-conditioning, inhabited by demons and other minor divinities. The balloon soars towards Nieuwenhuis's space where "there exists an

[124] Sloterdijk (2013)
[125] See Saraceno and Engelmann (2014) and my contribution to the installation catalogue.
[126] Ash and Thrift (2013)
[127] Ingold (2011)

opportunity, or at least a responsibility, to continue resisting and hope that there is such an outside, to think about the possibilities for a politics of the air free from the gravitational political forces that pull us down."[128] However romanticised this might be, it has the peculiar power to hide, even for a moment, the brutality of the ontological occlusion: from up here everything is revealed. Above all, the balloon manages to occlude the fact that even if one escapes an atmosphere by withdrawing from it, *one always ends up, sooner or later, always preconsciously, always affectively directed, into another atmosphere*. There is no escaping the continuous rupture into atmospheres. Yet, as Nietzsche writes, "there is no outside! But we forget this… How lovely it is that we forget!"[129] It is perhaps politically important to forget, to carry on with a different horizon, to believe in phenomenological ruptures.[130] Writing about a different balloon flight, Derek McCormack manages to connect the ontological and the phenomenological in a subtle atmospheric gesture that soars "through a distributed atmospheric field of circulating materials moving at differential rates from which obviously emotional geographies precipitate – narratives of hope, longing, sadness, despair, and joy."[131] The affect comes through the air and registers symbolically, emotionally and sensorially with the bodies between and in which it circulates. The solar balloon has allowed the emergence of an imaginary continuum of withdrawing affecting and affected bodies to rise into a global, elemental, excessive visibility.

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[128] Nieuwenhuis (2015a) 176
[129] Nietzsche (2005, page 175)
[130] For the necessity of illusion, see Philippopoulos-Mihalopoulos (2015)
[131] McCormack (2008, page 426)

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ECOLOGIES OF COMPARISON

An Ethnography of Endangerment in Hong Kong

TIM CHOY

DUKE UNIVERSITY PRESS

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6 AIR'S SUBSTANTIATIONS

Noticing Air

Hong Kong writer Xi Xi opens her experimental short story "Marvels of a Floating City," a mixed-media piece that weaves together brief narratives and reproductions of paintings by René Magritte, with a fantastic image of a metropolis—a thinly veiled Hong Kong—emerging from the sky.

> Many, many years ago, on a fine, clear day, the floating city appeared in the air in full public gaze, hanging like a hydrogen balloon. Above it were the fluctuating layers of clouds, below it the turbulent sea. The floating city hung there, neither sinking nor rising. When a breeze came by, it moved ever so slightly, and then it became absolutely still again.
>
> How did it happen? The only witnesses were the grandparents of our grandparents. It was an incredible and terrifying experience, and they recalled the event with dread; layers of clouds collided overhead, and the sky was filled with lightning and the roar of thunder. On the sea, myriad pirate ships hoisted their skull and crossbones; the sound of cannon fire went on unremittingly. Suddenly, the floating city dropped down from the clouds above and hung in mid air.[1]

I love this image. It transforms a city that can feel dense and overwhelming into a thing of quiet and delicacy. Xi Xi shows Hong Kong as a place moved by the slightest touch of a breeze, as a place that can become absolutely still. It reminds me of the Hong Kong I sometimes encountered on late-night walks past the government buildings, while taking the slow ferry between Hong Kong and Lantau Island, and at times while sitting on MTR

subway trains when, following the example of many others around me, I would put on my headphones and take a nap.

Xi Xi's conceit also turns Hong Kong into something like a natural object, something nearly elemental. The city's mercantile and military origins become almost atmospheric, a storm depicted by layers of clouds and a sky filled with flashes and roars. The pirates themselves—the British Lord Palmerston and the others—are absent in this picture (their presence is marked only by the crossed flag that is raised into the sky), but the meteorological impact they had in birthing the floating city is made clear.

Xi Xi's pairing of city and sky is fanciful and metaphoric—the images of dangling and floating recall the questions about an uncertain future that preoccupied Hong Kongers in the late 1990s—but for me, Xi Xi's image is particularly compelling because it also invokes something profoundly literal. Air is central to the understanding and experiencing of Hong Kong.

To explain what I mean by this, I need to tell another story of city and sky, this one just slightly less fantastic. In April 1999 Tung Chee-hwa visited the headquarters of the Walt Disney Corporation in Los Angeles. The visit was perhaps intended as a triumphant exercise of social capital, meant to perform and to buttress a relationship forged through a controversial agreement Tung had signed earlier that year between the Walt Disney Company and the Hong Kong government. The agreement amounted to a joint business venture. Disney would build a theme park in the Special Administrative Region, a park that would not only serve as a draw for international tourists but also (Tung hoped) provide service sector jobs to the increasing—and increasingly vocal—ranks of the unemployed in Hong Kong. In return, the Hong Kong government would be the primary investor. The agreement would be criticized roundly for its environmental oversights as well as for the economically vulnerable position it forced upon Hong Kong. At least in the Walt Disney Company, though, Tung had a supportive ally. They were in agreement: a world-class park for a world-class city was exactly what Hong Kong needed.

Unfortunately, Tung's visit to Los Angeles was marred by more doubt and criticism, this time from Disney itself. Michael Eisner, Disney's chief executive officer, took the opportunity to express concern about the poor air quality in Hong Kong, noting that it did not mesh particularly well with the family image that Disney so prided itself on cultivating. Eisner never said explicitly that Disney's continued participation in the theme park idea hinged on smog reduction. But people with whom I later spoke—shopkeepers, en-

vironmental activists, and taxi drivers alike—would interpret the event as more of a threat, as though Eisner had taken Tung aside and whispered in his ear that Disney would pull out if Hong Kong's air quality did not improve.

One could have remarked upon the irony inherent in this moment when a corporation based in, and associated so strongly with, smoggy Los Angeles faulted another city for its poor air, but Tung made no attempt to do so. Instead, he returned to Hong Kong and sheepishly reported the exchange to his advisers and to the Hong Kong public through the news media.

The newspapers had a field day. Hong Kong had just coughed its way through the most polluted winter in its recorded history. Many residents had checked themselves into hospitals citing respiratory problems. The poor air had also forced my partner and me to relocate from our apartment in Sai Ying Pun, an aging urban district in western Hong Kong where we had been living since our arrival, to a flat in a house in Mui Wo, a village on the coast of Lantau Island. Zamira had suffered three sinus infections in six months. It was time to move.

I remember feeling a guilty sense of relief when I read the news. The extremity of the air pollution—the worst in history—made Zamira's illness, and our move from city to village, count as a moment of participation in a genuinely Hong Kong experience. Until then, I had sought to cultivate indifference toward air and air pollution. Although we, like our friends, routinely avoided waiting or walking on busy streets because the air stung our eyes and throats, and though we often left the city on weekends to escape the pollution, I consistently refused to comment upon or even to notice the air. My justification was simple, if not simple-minded: the people I met in my first months in Hong Kong who were most vocally critical of the air quality were almost without exception expatriate businesspeople from the United States. I did not want to be associated with them. The air pressed upon me, for instance, at a cocktail party celebrating the publication of a book by the renowned Hong Kong landscape photographer Edward Stokes. I was chatting with a representative from the American Chamber of Commerce and his wife when it happened. Hong Kong has to see, she told me, that the environment is an economic problem. Hong Kong wanted to build this Cyberport, for instance, but who would want to come to Hong Kong to work if the air was so bad? If you could not even see? This was the first time, but certainly not the last, that I heard Hong Kong's air coupled with the future of its economy.

At the same time, many of my Cantonese-speaking, Hong Kong–born friends often vocalized their suspicions that politicians who built campaign

platforms on the topic of air pollution were motivated by selfish and middle-class interests. Such politicians were only trying to preserve real estate values for the properties of elites, they said. So, in what I considered an ethnographer's effort to immerse myself in an ethics grounded in Hong Kong's particularity, I tried hard to act as if the air stinging my throat were commonplace, not worthy of notice.

But Zamira's illness, the record-breaking winter pollution, and the Disney debacle together forced me to take notice of the air that had been swirling everywhere around, above, and through me and everybody else the entire time I had been in Hong Kong. I remembered then that during my first field visit to Hong Kong in 1996, when I had asked officials about the pressing environmental issues, air quality was always one of the first to come up. Not only that, but air had mediated ruminations about Hong Kong's impending political transition to Chinese sovereignty. "The real concern is transborder pollution," the official at the EPD told me during an interview months before the handover in 1997. "How will we deal with the air and water pollution that comes down from the mainland?" The air is framed as a threat from the north in these pre-postcolonial months. What remained to be seen, they said, was how the Chinese government would respond to Hong Kong's attempts to reduce air and water pollution in mainland China. We will soon see, they seemed to be telling me, what the implications of the handover will be. One activist told me explicitly that they were trying to lie low, and that rather than making any political demands they would concentrate on building relationships with mainland bureaucrats before the transfer of power.

This account of my gradual awakening to the significance of air mimes a standard trope in ethnography, that of the epiphany in, and of, the field. But it is also something else, or it can be if attention shifts away from my eventual ethnographic realization and focuses more closely on my initial attempts to disavow difficulties with the air. That disavowal was plainly an endeavor to distance myself from expatriates; it was a localizing and nativizing enterprise, one whose motivations were analytically untenable but nonetheless impossible for me to resist. If I confess that at stake in my initial disavowals was a naive dream of being a Chinese American anthropologist more able to stomach an everyday, everyman Hong Kong life than my imagined doppelgängers, the well-paid expatriates (including those of Chinese descent), it is only to point out that whatever lines of distinction I imagined—and whatever manners I saw available to identify with some people and to distance myself from others—themselves point to the key issue. Air

mattered powerfully in Hong Kong. It mattered in deeply felt, variegated, and variegating ways.

All That Is Air

Air matters too little in social theory. Marx famously described the constant change that he saw characterizing a "bourgeois epoch" as a state in which "all that is solid melts into air," and that provocative phrasing served in turn as a motif for Marshall Berman's diagnosis of "modernity" as a shared condition in which all grand narratives were subject to skeptical scrutiny.[2] Yet aside from signifying a loss of grounding, air is as taken for granted in theory as it is in most of our daily breaths. This is unfortunate, because thinking more about air, not taking it simply as solidity's opposite, might offer some means of thinking about relations and movements between places, people, things, scales that obviate the usual traps of particularity and universality. These traps themselves, it will turn out, are generated through an unremarked attachment to solidity.

To understand this attachment, it is helpful to revisit the context and afterlife of Marx's commonly cited line. The passage where it appears is about a sweeping change:

> The bourgeoisie cannot exist without constantly revolutionising the instruments of production, and thereby the relations of production, and with them the whole relations of society. Conservation of the old modes of production in unaltered form, was, on the contrary, the first condition of existence for all earlier industrial classes. Constant revolutionising of production, uninterrupted disturbance of all social conditions, everlasting uncertainty and agitation distinguish the bourgeois epoch from all earlier ones. All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away, all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life, and his relations with his kind.[3]

Marx argues here that with capital as such comes a constant revolutionizing of society. This is a liveliness of capital. When surplus value is a motivating abstraction, what once were means to generate differential value—the instruments of production—can become a fetter to that project when those instruments are fixed and ubiquitous. A technology might at one time

lower the costs of production or enable new forms of goods and markets, but if that technology becomes ubiquitous in a given market through others securing similar means, the advantage it offered disappears. One might try to revive dead capital through new markets, but if it cannot be resuscitated, something livelier must take its place.

Marx's rendering of this process of endless dynamism hinges on a remarkable figuration of solidity. On the one hand, solidity stands for fixity and reliability. The phrase "all that is solid" renders firm industrial society and the long-standing nature of relations among people and between people and land. On the other hand, this very fixity is itself *historical*. Solidity, in other words, is not fixed at all. Marx materializes this paradox of simultaneous fixity and nonfixity in his language, through his images of relations being "fast-frozen" or "ossified," for these images beg the question of what existed before the freezing and ossification. His images of solidification as a process imply a prehistory, one of pre-solidity.

There are typically two responses to such an image of the world where solidities dissolve. A philosopher might strive for some contingent conceptual fixities to make sense of this swirling about. Marx does precisely this in his analysis, and it requires an unavoidable universality. We hear in the passage a mantric repetition of "all." "All social conditions," "all fixed, fast-frozen relations," "all new-formed [relations]"—together they aggregate, yielding an image of a whole that in turn gives way to the epochal atmospheric world of capital. Similarly, social theorists since Marx have sought to develop general terms, such as "flexible capital," "postmodern condition," and "neoliberalism," to grasp and contain a world of dynamism and change.[4]

Another response, one common among cultural anthropologists today, is to refuse the universalizing gesture and perhaps even the very project of the concept. This might take the form of repudiating either the claim that "everything" is melting or the idea that there can be "whole relations" in the first place. Such abstractions kill, this response goes, doing violence to particular human lives and practices that lie outside the terms of the analysis, and such lives are accessible only through empirical work.

The first response is the one usually charged with being up in the air, with not being concerned with concrete details, particular conditions, specific lives on the ground; but in fact, both responses are of a piece. Both responses, whether universalizing or particularizing, seek solid analytic ground; and both find their ground through resort to a "one." This is so whether the one is the unifying one of the "all," or the irreducible particular

one refusing subsumption into the general. The conceptual one and the empirical one are a conjoined pair, and both suffer vertigo without firm footing.

Air is left to drift, meanwhile, neither theorized nor examined, taken simply as solidity's lack. There seems at first to be no reason not to let it. When solidity is unconsciously conflated with substance, when only grounding counts for analysis, air can only be insubstantial. We are stuck with the twinned ones—universal and particular—grounded, fixed, and afraid.

Environmentalists in Hong Kong, however, would press us on this attachment to the ground, as would Marx himself. The environmentalists would ask, Is not this stuff floating above and around us itself deeply substantial? As for Marx, we should remember that his claim is ultimately about a dialectics of solidity. Solidities all have a pre-solid past, and air lies in solidity's future. As he declares in a speech during the anniversary of the *People's Paper*, "The atmosphere in which we live weighs upon everyone with a 20,000 pound force. But do you feel it?"[5] It would be a mistake, in other words, to search only for ground when above and around us is substance aplenty. Our living with this substance, furthermore, is neither universal nor particular. Air is not a one, it does not offer fixity or community, but it is no less substantial. The question is whether we can feel it.

Hong Kong might help us feel it. From a certain point of view, there is no "air" in itself. Air functions instead as a heuristic with which to encompass many atmospheric experiences, among them dust, oxygen, dioxin, smell, particulate matter, visibility humidity, heat, and various gases. The abstraction of air does not derive from asserting a unit for comparison or a common field within which to arrange specificities, but through an aggregation of materialities irreducible to one another (including breath, humidity, SARS, particulate, and so forth). Thinking about the materiality of air and the densities of our many human entanglements in airy matters also means attending to the solidifying and melting edges between people, regions, and events.

This might help us to imagine a collective condition that is neither particular nor universal—one governed neither by the "all" nor through the "one nation, one government, one code of laws, one national class-interest, one frontier, and one customs-tariff" that Marx envisioned, nor even the "one planet" of mainstream environmental discourse. Instead, it orients us to the many means, practices, experiences, weather events, and economic relations that co-implicate us at different points as "breathers." I like this term, "breathers," which I borrow from environmental economics; it refers to those who accrue the unaccounted-for costs that attend the production

and consumption of goods and services, such as the injuries, medical expenses, and changes in climate and ecosystems. I like the term because its very vacuousness constantly begs two crucial questions that are both conceptual and empirical: What are the means of counting costs? And who is not a breather?

• • •

The story of air's substantiation in Hong Kong hinges on acts of condensation, and this chapter engages in parallel acts to condense that story. Consider how the pollution-monitoring stations dotting Hong Kong yield a measurement for respirable suspended particulate. Enclosed machines on rooftops and streets ingest millions of mouthfuls of wind a day, calming it so that the particles it holds can be collected to count, to accumulate enough of the particular for it to register as weight, as substance worth talking about. Miming this method, I collect the details in a diffuse set of contexts: the production of air pollution as a local and global medical concern, the material poetics of *honghei* (air) in daily discourse and practice, the acts of large- and small-scale comparison signaled by air, and the transformations that condense Hong Kong's air into measurable particles and then further into a particular, yet internationally recognized, metric for risk.

In short, four forms of air concern me: (1) air as medical fact, (2) air as bodily engagement, (3) air as a constellation of difference, and (4) air as an index for international comparison. Ultimately, my aim is to gain a deep understanding of all of them and to move seamlessly between their methods and registers. Rather than focusing on just one, I make a start in each of them because conveying the dispersal of air's effects and its substantiations is one of my chief aims. This has produced a text that can seem diffuse; its argument requires some work to condense. But that is exactly what people concerned with air must do: turn the diffuse into something substantive.

Air and Dying

Climatologically, there are two Hong Kongs. Beginning in May and June, the air in Hong Kong swells as winds blow in from the tropical south, bringing heat and humidity. Temperatures will range from the mid-eighties to the high nineties Fahrenheit, while the humidity hovers around 95 percent. The air sticks to you as you walk, forms a sheen on your skin as you move from

an air-conditioned bus, taxi, or building to the outside. In the late summer, there are the typhoons—great oceanic whirlwinds that occasionally batter the small island with wind and rain as they spin through the Pacific. In colloquial Cantonese, typhoons are called *da fung*, the beating wind.

Then, around late September, the winds begin to shift. Cooler and drier air gradually blows in from the north, across mainland China and Asia. The temperatures can plunge into the mid-forties—as they did in the winter of 2000, when the streets filled with puffy North Face jackets—while the humidity drops to 70 percent. In these drier months, Hong Kong can feel temperate. In the summer, the air in Hong Kong is heavy with heat and water, but in the winter months its weight comes from a different kind of load as the cool, dry winds sweep the smoke and soot from the skies above China's industrial factory zones into Hong Kong.

It is these sooty winter months that most likely motivated Michael Eisner to pull Tung Chee-hwa aside during Tung's visit to Los Angeles. If Eisner's criticism of Hong Kong's air was indirect and vague, the critiques voiced a few years later by Hong Kong doctors were specific and direct. In 2001 and 2002, faculty from the departments of Community Medicine at the University of Hong Kong (HKU) and the Chinese University of Hong Kong (CUHK) published separate articles in internationally known scientific journals linking Hong Kong's air pollution and declining health. The first of the two, "Effect of Air Pollution on Daily Mortality in Hong Kong," appeared in the journal *Environmental Health Perspectives*. The second, published in *Occupational and Environmental Medicine* by researchers from CUHK's Department of Community and Family Medicine, was titled "Associations between Daily Mortalities from Respiratory and Cardiovascular Diseases and Air Pollution in Hong Kong, China."

The articles' findings were chilling. Both studies concluded that acute air pollution had significant short-term health effects. More people died of cardiovascular or respiratory illness on days with bad air quality than they did on days of good air quality. The HKU study also compared warm- and cool-weather data and found that the chance of pollution-correlated mortality was statistically higher in the cool season.

Both articles take pains to locate themselves in a citational network. I mention this not to argue that citational networks are invoked to confer authority upon the articles, a point well argued by others already.[6] Instead, I am interested in the warp and woof of the network being woven, for it lends a specific character to the objects and political substances emergent in it.

One way to see how is through the titles of some of the citations that form the network:

"Particulate Air Pollution and Daily Mortality in Detroit"
"Air Pollution and Mortality in Barcelona"
"Particulate Air Pollution and Daily Mortality in Steubenville, Ohio"
"Air Pollution and Daily Mortality in London: 1987–92"
"Air Pollution and Daily Mortality in Philadelphia"
"PM_{10} Exposure, Gaseous Pollutants, and Daily Mortality in Inchon, South Korea"
"Daily Mortality and 'Winter Type' Air Pollution in Athens, Greece"
"Air Pollution and Daily Mortality in Residential Areas of Beijing"

There is a remarkable, almost numbing, uniformity to the titles. They share a syntactic structure, differing from one another through a paradigmatic substitution of terms within that structure. In each, a compound subject is first offered through a conjunction of air pollution with mortality, later to be positioned through a locating "in." Though there are minor variations in the first half of the titles—"air pollution" might be modified as "particulate air pollution" or "winter type air pollution"—the most significant transformations take place in the second half, the prepositional phrase naming a particularity of place.

In this structure we discern something about the workings of exemplarity as political method. Through the mustering of a network of almost identical examples, and by giving their articles almost identical names, the doctors make Hong Kong an example of a much larger problem. At the same time as that example draws power from the network, it also lends stability to that network. The co-examples as a whole, as a network, substantiate a conjunction of objects—air pollution and death—differentiated only by place.

One thing to notice here is the play of particularity in the formation of political substance. Rather than jeopardizing its stability, the proliferation and accumulation of particulars is key to the citational network's existence. The production of Hong Kong air is both a localizing and a globalizing project. Localizing because it carves out the uniqueness of Hong Kong. It lends it specificity; the hallmark of that last prepositional phrase is place-based specificity. Globalizing because it performs membership in an international community of atmospheric and medical science and in an international, global problem.

Equally important, the common form of the titles signals common

method. Both articles were "retrospective ecological studies" employing "time series analysis," a method that amounts to statistically correlating the "number of people dying on a particular day" (or a day or two later) with meteorological data and air pollutant concentrations over a long-term period.[7] The statistical method used was a Poisson regression model "constructed in accordance with the air pollution and health: the European approach (APHEA) protocol."[8] The near identity of the titles in this particular citational network, in other words, is premised upon a near identity of technique. It is not enough to assert that Hong Kong's deadly air is one example among many in the world; co-exemplarity is actualized through the standardization of technique.[9]

This simultaneous evocation of general problem and specificity is resonant with dynamics in other spheres. It bears comparing, for instance, with the collecting, formatting, and iterating of data in environmental informatics, creating a general problem precisely by arraying and juxtaposing particularities. As Kim Fortun observes, however, environmental informatics enables this process to be iterated across a range of sites and types of information that would be impossible to encompass in the space of a single study.[10] The Hong Kong daily mortality studies discussed here would be but two among a vast library of data sets for information engineers like those Fortun describes, raising the question of the extent to which such studies might be produced in anticipation of themselves being informatted and networked. The carving out of specificity through geographic location also underscores Sheila Jasanoff's observation that specificity plays a vital role today in legitimating claims of intellectual innovation and ownership.[11] What becomes clear looking across these topoi is that while specificity is at play in all these moments, one cannot take for granted what specificity means. There is no specificity in general, and the real work of specificity must be gleaned from the pragmatics of the specific knowledge practices in which specificity as a concept is figured.

To understand this, let us examine the specific conditions in which the citations appear in the Hong Kong articles. Consider this excerpt from the HKU study's conclusion:

> In setting air pollution control policy from a public health viewpoint, it is important to identify the health effects of air pollutants from local data. Because of the lack of data, there are few studies based on daily hospital admissions and mortality in the Asian Pacific region. For hospital admis-

> sions there has been only one study in Australia (36) and two in Hong Kong (30,37). For mortality studies, there have been one in Beijing, China (38) based on 1-year daily data, two in Australia (36,39), and two in Korea (40,41). Our report should contribute to the understanding of the effects of air pollutants in this region and may clarify the differences in effects and mechanisms between Western and Eastern populations.
>
> Local data on health effects of air pollution are required for setting standards and objectives for air pollution controls. *When local data are not available, foreign data may be helpful, but they may not be relevant or applicable because of a difference in climate or other conditions*. Our findings in this study provide information to support a review of air quality objectives with consideration of their effects on health.[12]

Here, the network (plotted by the integers corresponding with the citations at the end of the article) is invoked through a naming of its holes, "the lack of data." The naming of the general problem is indistinguishable from the claim for the primacy of the specific.

The explicit value of the Hong Kong study is marked as clarifying differences in effects "between Western and Eastern populations." By identifying Hong Kong's warm, humid summer and cool, dry winter, the HKU study reminds us that we are in the subtropics; and the specific ways in which it cites its network of relevant citations give that reminder a certain freight. It identifies and locates the work of Hong Kong doctors within the terms of a center and periphery of scientific practice. As scientists in the periphery, the researchers must negotiate a double bind not unlike the one Lawrence Cohen describes facing gerontological organizations and authors in India in the 1970s, who, in appending "India" to their names and publication titles "claim[ed] local autonomy from internationalist [gerontological] discourse, but [did] so through a reassertion of epistemological subordination."[13]

The Hong Kong doctors navigate this bind through an appeal to local appropriateness: "When local data are not available, foreign data may be helpful, but they may not be relevant or applicable because of a difference in climate or other conditions." Note, they do not say that the category does not apply "here" or that air pollution is a Western problem; they simply maintain that better, more local data is needed. This is a supplementary strategy, one that has the potential to disturb, even while leaning upon, the centrality of temperate studies: "This study provides additional information for our previous study on hospital admissions (21), and the many time series

studies on air pollution and mortality in temperate countries (1–11,13,15,17–19,28,29,33,35,38,39)."[14]

The Hong Kong studies "contribute to" and provide "additional information for" the networked assemblage of other conjunctions of air and mortality "in temperate countries," and in doing so, they help it grow. Yet at the same time, their act of "adding to" articulates through implication an inadequacy in the apparently whole original to which they contribute.[15] The Hong Kong doctors' exemplification of Hong Kong names geographic unevenness in—even while extending the reach of—an emerging coalescence of scientific and political substance.

This emergent substance is fragile stuff. Daily mortality studies face criticisms that they establish no causal link or proof of impact in the long term. Some epidemiologists, for instance, argue that even if one can show that the number of people dying on a day with high air pollution is significantly greater than on a comparable day with lower pollution, the early deaths might be of people who had little time left to live anyway.[16] Those most vulnerable on high-pollution days are those with fragile health or in advanced stages of terminal illness, the argument goes. This is termed a "harvesting effect." Those who died were going to die soon; they were simply harvested early. Long-term cohort studies are needed to determine precisely how many, if any, person-years have been lost. Only with such data, this argument concludes, can the extent to which air pollution decreases life be understood.

Such a refusal to recognize air's daily effects by scaling time out seems absurd at first, but we should recognize it as a logical side effect of rendering illness and health into prognosis. As Sarah Lochlann Jain illuminates in her analysis of "living in prognosis," a prognosis—which assigns people a certain percent chance of being alive in the next number of years based on when others considered to be in comparable medical and demographic categories have died—puts one in the mind-wrenching position of living counterfactually, always juxtaposing one's living against aggregated odds of dying.[17] The analytic of harvesting simply takes this head-wrench to the extreme, by not finding a death today worthy of note simply because most others in the same position, whether good air day or bad, did not live that much longer.

Substantiating Hong Kong air as a dangerous substance will require crunching not only numbers. It will require grappling with how to think about a cause of death when causes are multiple and overlapping, and how, when lives and causes are complex, to say when it matters that a person dies

today—and not tomorrow or next year. These efforts are crucial if air pollution's effects on health are to be grasped.

At the same time, they run the risk of narrowing our sense of what matters in human-atmospheric relations. When we ask how many more people die on particularly polluted days than would have if the air were clear, death becomes a proxy for air's effects, and death itself is rendered a problem of lost time—which in turn prompts the demand for more accuracy in counting the time in person-years lost. (How many person-years will be spent counting person-years?) But it bears remembering that air's human traces are found not only in those who die, their times of death, or total person-years lost, but in the fabric of living.

Air and Living

I collapsed when I got home, my stomach somersaulting like it had at the Tung Chung Citiplaza, where I had needed to stop at the public washroom instead of catching my connecting bus. A fever hit me that night, leaving me weak and useless. The next morning, I called Wong Wai King, my collaborator in Tai O, to cancel our appointment.

"You're sick, eh? Yeah, the honghei these days has been really bad."

I found this strange. The air hadn't seemed that bad. But I spoke to others, who nodded knowingly and recalled that the air had been particularly wet on that hot, muggy day.

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The link forged by the doctors between air and health was not novel or isolated. Nor, as Wong Wai King and others helped me to see, was air's impact on health in Hong Kong limited to its particulate load. Already circulating was an existing discourse of honghei and health. Reviewing my notes back in San Francisco, I noticed this entry from August: "Ah Chiu has been sick. She got a cold or something. It's a common thing to get colds out here in the summer. Nobody thinks it's strange, because they all know that when going in and out of air conditioning, you can get really cold and then sick." My notes and memories are dotted with such commentaries. Sometimes, I was told, it was too hot. Other times it was cold, dry, or wet.

In traditional Chinese medicine (TCM) texts, honghei (Mandarin: *kōngqì*)

denotes one of two sources of acquired *hei*. The other source is food. Hei, widely recognized in its Mandarin pronunciation, *qi*, is the fundamental life force in TCM, often translated as breath. Honghei is thus a breath in two senses; it is a source of vital breath, and it is breathed. In everyday use, honghei refers to the air in one's surroundings.

Though breath is vital, wind is dangerous. "Wind is the first evil," my acupuncturist, Marliese, explained to me. "It opens the body to secondary ills." Historian of science Shigehisa Kuriyama offers a beautiful account of the central role played by wind (Mandarin: *feng*; Cantonese: *fung*) in the history of Chinese medical conceptions of the body. He highlights the tension that existed between, on the one hand, feelings of an ultimate resonance between the body's breath and the surrounding winds and, on the other, anxieties about human subjection to chaos, where humans were opened to irregular and volatile winds by their skin and pores. Through close study of medical and philosophical texts, Kuriyama shows clearly that "meditations on human life were once inseparable from meditations on wind," in both Chinese and Greek medicine.[18]

What most strikes me in Kuriyama's account is his attention to language—both in the ancient texts he studies and in his own writing. Wind and air whistle through his writing as much as they do through the texts he analyzes. Listen, for instance, to his discussion of the connection that the philosopher Zhuangzi drew between earthly winds and human breath.

> The winds of moral suasion, the airs that rectify the heart, and now the heavenly music of gaiety and sadness. All these bespeak a fluid, ethereal existence in a fluid, ethereal world. A living being is but a temporary concentration of breath (*qi*), death merely the scattering of this breath. There is an I, Zhuangzi assures us, a self. But this self is neither a shining Orphic soul imprisoned in the darkness of matter, nor an immaterial mind set against a material body. Anchored in neither reason nor will, it is self without essence, the site of moods and impulses whose origins are beyond reckoning, a self in which thoughts and feelings arise spontaneously, of themselves, like the winds whistling through the earth's hollows.[19]

By allowing the air to permeate his own figurations and similes, Kuriyama conveys to his readers Zhaungzi's theorization of human permeability and impermanence more vividly and viscerally than a less writerly account could.

Later Kuriyama will show how much more dangerously the winds are figured in subsequent texts, and it is this sense of wind's danger that my acupuncturist in California inherits through her study of TCM.

Air's meanings in Hong Kong seem to exceed this classical medical genealogy. Among people I have known in rural and urban Hong Kong, good fung characterizes good places. Wind's ubiquity, however, and the way it wends its way into everyday talk recall the inseparability of wind and life that Kuriyama describes and the lyrical trace of an imminently atmospheric sense of the self and health. Meditations on life through wind are as prescient as ever.[20]

• • •

In Tai O, the air is on the tip of people's tongues. "Hello, good day. Nice fung today, isn't it?" The old men sit on the benches by the Lung Tin Housing Estate, Dragon Field, facing the road that connects Tai O to the rest of Lantau Island, watching the hourly bus come in with visitors. Their shirts are loose. The breeze curls through Lung Tin, finds Wong Wai King sitting on the concrete steps outside her bottom-floor apartment. She sips some sweet water, closes her eyes, and plays her *guzheng*. "*Wah, hou shufuhk*," she tells me. "Ah, it's so very *shufuhk*."

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The word *shufuhk* means "comfortable," but also more. When people say they're not shufuhk, they mean they're not well. Conversely, when Wong Wai King and others tell me that they're shufuhk, they tell me that they are experiencing a saturating pleasure. Like a cool breeze on a hot sticky day. A clean bed. Or the way a cup of tea might warm you from the inside when you're cold. The word is ubiquitous.

Places are made into living things through a blend of landmark and language, as anthropologists of place have taught us to see, and the air in Hong Kong is undeniably part of the rhetoric of its place.[21] But air, polluted and otherwise, is a daily materiality as well as a symbolic field. To explore a material poetics of place, and air's function with it, we need to ask after the material and meaningful ways in which air enters into human and geographic life as such. For the notion of a poetics of place to have any teeth, for it to do more than simply legitimate linguistic study as a study of something linked

to the material world, we must also go after the nonverbal ways air operates poetically. How does air serve as a meaningful and material unit in the building of Hong Kong? Let us take an atmosphero-poetic tour.

Some of the neighborhoods I choose for this tour are among Hong Kong's most famous. Central is the financial heart of Hong Kong and its government, whose illuminated towers, set against a foreground of the green waters of Victoria Harbour, adorn most of the stereotypical tourist images of Hong Kong. Less celebrated internationally but well known both in Hong Kong and in tourist literature is Mong Kok, a district on the Kowloon Peninsula. For many, Mong Kok is the antithesis of Central. Mong Kok is commonly held to be more Chinese than Central. While English appears on shop signs and restaurant menus in Central and sometimes comes out of shopkeepers' mouths, it is rare in Mong Kok. Whereas Central offers at least some Western comforts, Mong Kok caters to Hong Kong Chinese and to tourists seeking a flavor of Chinese alterity within Hong Kong.[22]

Tai O should be considered a part of this tour, along with Lung Kwu Tan and Ha Pak Nai. Tai O, as we saw in chapter 2, is a popular destination for domestic and foreign tourists, though not long ago it was considered a dirty backwater. Lung Kwu Tan and Ha Pak Nai, which we encountered in chapter 4, are relatively less well known villages in Hong Kong's New Territories, hemmed in by a power station and a landfill and facing the impending construction of a municipal waste incinerator. With their inclusion, another axis of difference becomes clear. Central and Mong Kok might in isolation evoke an imagined opposition between Western and Chinese in Hong Kong, but when Tai O, Lung Kwu Tan, and Ha Pak Nai become stops on our tour, Central and Mong Kok find themselves partners in urbanity set against the rural New Territories.

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Central. In the winter the air in Central sweeps in dark swirls through Connaught Road, blowing under squealing double-decker trolley cars before whirling up Pedder Street toward Lan Kwai Fong, Central's famed restaurant and bar area. It chases the heels of trundling buses and racing taxis, and flings gusts of soot at the ankles of the pedestrians waiting at the crosswalk, who, almost in unison, lower their heads and cover their mouths and noses with a hand or handkerchief—a loosely synchronized nod and an almost instinctive gulp of held breath—as the wake of air washes over them.

Lung Kwu Tan. In Lung Kwu Tan and Ha Pak Nai, two villages in Hong Kong's Northwest New Territories, the air smells cleaner at first; it doesn't smell of diesel. There are fewer buses out here. Fewer taxis. But it does smell of garbage, of the garbage water that leaks from refuse trucks. People talk about the dust that settles on their vegetables from the cement factory's smokestack. Then there are the flies that fill the air, making you want to keep your mouth more tightly closed while breathing. Now residents are worried about what else might come from the air if the government builds its incinerator here. Dioxins, says Rupert, the most poisonous substance humans have ever created.

Still, the air is on the water, and this yields cool breezes. On weekends it fills the sails of windsurfers and carries the scent of visitors' barbecues, even if the occasional atmospheric shift wafts reminders of the cement factory, power station, and landfill nearby.

Mong Kok. In Mong Kok, a neighborhood on the Kowloon Peninsula that has been called the most densely populated area in the world, the winter winds are as sooty as those in Central. Dust expelled from the backs of abundant buses, trucks, and taxis barely settles before it is stirred up again. Pedestrians cross the street with the same nodding gestures as in Central. Off the street, though, the winter wind might find itself broken by a crowd, trapped and thawed by the press of people gathered to shop and play.

The same is true a bit farther north, in Yau Ma Tei, where there is also the night opera. Two women are performing, one middle-aged with glasses, leaning deliberately toward her microphone under bright incandescent lights. The musicians sit to the left, one smoking a cigarette while he plays his *erhu*. The music, the voice, they quaver. They sound like old radio. The air is full too, with the sticky smell of cow parts being stewed, durian, skewers of pork, oyster omelets, clams and black beans. The scent of diesel fades into memory, and the cold air, defeated, rises to the overlooking skyscrapers in warm ripples.

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We have taken a slight detour from the issues of health that first brought us to consider the air. But we have retained the issues of the body, the question of immediacy—the coughs, the instinctive intakes of breath. Part of air's substantiability in Hong Kong comes from the fact that it is always breathed.

The poetic mattering of Hong Kong's atmosphere encompasses not only

Wong Wai King's rhapsodic "Wah, hou shufuhk," but also her sip of sweet water, the placement of her chair, and the coughs and nods of the pedestrians aiming to cross the street in Central. Air's poesis, the coproductive engagements between people and air, range from commentary, to breath, to avoidance, to the flip of an air-conditioner switch. Put another way, air is not only an object of cultural commentary, and not only a nonhuman materiality always already enmeshed in webs of social and cultural practice. It is something embodied that engages with humans through bodily practices. The smell, breath, wind, weather, typhoon, air conditioning, air pollution, height, verticality, science, sound, oxygen, smoking. The tactility of the atmosphere.

Anthropologist and musician Steven Feld has argued that sound and voice provide a useful point of entry for apprehending relations between person and place.[23] He identifies the sonic resonance of the human chest cavity as a central feature of the links and feedback loops between people and their environments. How similarly fruitful might an anthropology of air be, an anthropology of this stuff sensed in and through the moment of bringing breath into the body, or at the moment when wind opens the body to ailments? Air muddies the distinction between subjects and environments, and between subjects. This thickness and porosity rendered by air is part of what makes the air and the airborne such deeply felt elements. Bodies may be, as the geographer David Harvey argues, intersections of large- and small-scale spatial practices;[24] but if bodies are an intimate location of effects and agencies, air is the substance that bathes and ties the scales of body, region, and globe together, and that subsequently enables personal and political claims to be scaled up, to global environmental politics, and down, to the politics of health.

Air's Comparisons

In August 2000 a feature entitled "A Breath of Fresh Poison" was published in the *South China Morning Post*. In the article, readers are introduced to a sympathetic character, Fred Chan Man-hin, who had recently returned to Hong Kong from Canada to start a company. He initially "planned on being here forever," he tells the *Post*, but "the pollution has affected my decision. I can't work and be sick all the time." Today Chan "avoids his office in the Central business district because the pollution gives him dizzy spells and migraine headaches. He has spent tens of thousands of dollars on doctors and tests

to find a cure for the allergies, viruses, and exhaustion that he cannot seem to shake."[25]

The article throws into relief a signature feature of air's substantiation as a problem in Hong Kong. It does not merely recount Chan's unshakable health woes; it makes a pointed comparison. Chan initially left Hong Kong for Canada, we are told, and he returned to make his fortune, but now the pollution might affect his decision to "be here forever." If air constitutes a danger in Hong Kong, part of its threat derives from its capacity to serve as an index for comparing Hong Kong with Canada and other places.

This capacity of air for comparison first became evident to me through my family, particularly through jokes about how predictably those who do not live in Hong Kong get sick when they visit. My mother's cousin, Ling, playfully chides her when she falls ill, for instance, when my parents visited Hong Kong near the end of my fieldwork. "You, your cousin Maggie, and your brother To—you all get sick whenever you come back to Hong Kong." My mother falls ill almost every time she visits Hong Kong, as do I. Ling knows this well, as we usually go to her or her husband for antibiotics. "You're not *jaahppgwaan*, not accustomed, to the air," Ling says. "Will you still visit?"

Will we still visit? This simple question draws us back to the landscape photographer's cocktail party, to my conversation with the American Chamber of Commerce representative and his wife, who wondered aloud how investors could be expected to come to Hong Kong if the air quality continued to deteriorate. It echoes Disney's admonishment to Tung. Air is not only an index of health. It is an index for comparing livability, well-being, global attractiveness.[26]

I cannot leave the matter of air's comparability at this level of global comparison, for it misses some of the subtle comparisons and distinctions that operate within the city-state. We are now acquainted with the air of some of Hong Kong's neighborhoods, its qualities, and its dangers; now questions of justice and equity beg to be asked. How are Hong Kong's air spaces distributed? Who gets to occupy those with the cleanest air? Who breathes the street? Who breathes mountains? Who breathes the sea? Who breathes flies?

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A few weeks after moving to Mui Wo, I returned to Sai Ying Pun to visit with the fruit vendor, Mrs. Chau. Ah, you've come back, Mrs. Chau said, loudly enough for passersby to hear. I smiled, a bit embarrassed, and replied that

the oranges looked good. I asked her to pick some for me, and for a glass of juice, and we chatted for a while there on Mui Fong Street.

I missed Sai Ying Pun, I told her. Mui Wo was nice, but it wasn't as convenient. There were also all the mosquitoes, I continued. Expecting some sympathy, I offered my arms to show her my mosquito bites, but Mrs. Chau dismissed them with a wave and a laugh.

Sure, there are mosquitoes, she said. But I'm sure the honghei is much better there.

Of course. Of course honghei mattered to Mrs. Chau, who worked every day on the busy corner of Mui Fong Street and Des Voeux Road, just down the street from one busy bus stop, where diesel buses pulled in nearly every minute, and across the street from another. Hillary, the stationer down the street, at least had a door between the street and his shop, and his shop was air-conditioned.

• • •

Far from uniform, Hong Kong consists of pockets. Studies in the loosely Marxist or critical geographic tradition take this as an assumption—that there are social inequities, mapped and realized through spatial distinction. Through their lenses, we discern a geographically uneven distribution of environmental harm, where the rich have access to good air, while the poor are relegated to the dregs, to the smog and dust under flyovers or on the streets.[27] One can, in other words, discern a political-economic geography of air. The poorest air quality was initially in the urban areas, in the industrial zones. Now the bad air is being exported, as Hong Kong companies relocate their factories in Guangdong province on the mainland, where labor costs are lower and environmental standards more lax. But then the pollution comes back in those notorious winter winds.

These arguments help to ground the air in a solid sociological critique of social and geographic stratification; for this reason they are politically vital.[28] At the same time, such fixings need less rigid company. When mapping the spatial distribution of social inequity, an account of air must at some point leave land-based maps, for they can divert us from the movements of air and breathers alike—not to mention mobile pollution sources, such as the taxis, buses, airplanes, and cargo ships crucial to the circulations of Hong Kong's industries. To the geography of air and the dialectics of air and capital, I add three corollaries: (1) air is made not only in emissions but

also in the respiration and movements of breathers; (2) neither those who emit particulate, the winds that carry it, nor those who breathe it sit still in places; and (3) as Kuriyama reminds us, there has always been more to air than particles.

• • •

The stratification of air spaces in Hong Kong is loosely tied to income, and incomes and occupations are also racially marked. Expatriates, with their generous compensation packages, can to a far greater extent than most people in Hong Kong choose to live somewhere clean and central. Because expatriates are visibly different, air spaces are visibly marked by the racialized and classed bodies that live, work, and play in them.

The Peak and the Mid-Levels have long served Hong Kong's elite as airy refuges. Almost from the moment British colonists occupied the small island off China's southern coast, they turned toward the peaks that formed the dramatic backdrop for the harbor they so desired, looking upward for some respite from the summer heat and humidity. If for mountaineers the staggering heights of snowcapped peaks presented a dream of sublimity and transformation, the Peak in Hong Kong offered to colonists a more mundane yet perhaps equally treasured transcendence of place, time, and air.[29] Even relatively recently, civil servants have had privileged access to apartment buildings high up.

In colonial times, people cared mostly about heat and humidity. The winter winds, whose passage through the landmass of greater Asia lent them coolness and dryness, were greeted with great pleasure. Today, that dryness and that passage through China have made winter less popular than it used to be. Real estate up high continues to be prized; now, though, it is valued not only as an escape from the hot, muggy summers but also because it promises at least some relief from roadside pollution and congestion, as well as convenient access to work and play.

The Mid-Levels, known in Cantonese as *zhong saan kui*, or the "mid-mountain area," are found a bit downhill from the Peak, and they too serve as something of a refuge from the soot below. The apartment towers are spaced farther apart than in the neighborhoods at lower altitudes, and there are fewer cars. Commercial skyscrapers are less prevalent up here, and the common mode of commuting here is the longest covered outdoor escalator in the world—the same one that stars in Wong Kar-wai's film *Chungking Ex-*

press. The escalator descends into Central from the top of the Mid-Levels in the morning, carrying not only local and expatriate professionals on their way to the office, but also domestic workers heading down to the markets to buy the day's groceries. Later, at 10 a.m., the escalator will reverse itself so they won't have to climb the many flights of stairs back to their employers' homes. Scores of restaurants and bars have sprung up around the escalator. The escalator and the easy commute it offers into Central have made the terraced streets of the Mid-Levels a pocket of real estate that is even more highly valued today than it was in colonial times.

Much of Hong Kong seems designed to get off the ground—into the air, and out of it. In colonial times, the English built their mansions in the Mid-Levels and Peak. When I walk with Hemen, a representative of the Tsing Tao Beer Company, he wends his way expertly through Wanchai, a government and nightlife district on Hong Kong Island, without ever touching the ground. We spend the day on the walkways that link this hotel to that shopping center. Some walkways are covered, others enclosed. Up here, we avoid the cars and the exhaust. My grandmother and I got lost once in these walkways. I remember how she pointed down to the street. There, she said, that's where I want to go. How do we get there? We never made it—we were lost in the flyovers.

• • •

Air is like food, essential to human life. Any anthropology worth its salt, however, asks after the meanings of the essential and its manifestation in material and semiotic constellations of power. Writing of food and eating, Judith Farquhar observes that "a political economy of eating emphasizes the uneven distribution of nutritional resources, while a political phenomenology of eating attends to the social practices that make an experience of eating."[30] For an adequate account, both ends of the analytic pole are necessary, as is everything in between. Air similarly calls for an understanding of its distribution and an emic analysis of its presence and distinction in acts of living. Like foods and tastes, air is enrolled in projects of social, racial, ethnic, and cultural distinction. When diasporic Chinese find the air in Hong Kong or China unbearable, their coughs, comments, and airplane tickets distinguish person and region. Consider also how atmospheric qualities figured in colonial poetics of difference.[31] The Chinese "do not suffer from the oppressive heat of the lower levels during the summer months as Europeans

do," theorized the signatories to a petition in 1904 to create a "Hill District" for Europeans.[32] Air marked the moments when colonists grasped for something to concretize their deep unease—a sense that all around them, permeating everything, was difference.

Air's Index

We have seen that people in Hong Kong have a number of techniques for reading the air—dirtiness, wetness, heat, breeze, height. And we have seen how threats and health are substantiated through air's breezing and breathing. In this section, I want to look at one of the state's measures. Air's substantiations, as we have seen them thus far, present a mess for a planner or politician. To facilitate communication and policy, they need something easier to evaluate—a measure that can be translated back into coughs and particles, if need be, but that is simpler and more encapsulating. Little wonder that air, an index of so much, should have an index of its own.

The Air Pollution Index (API) in Hong Kong is calculated in a manner similar to that of other countries such as the United States, Australia, and Mexico. Air pollution monitoring stations throughout Hong Kong collect data on several target pollutants: sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and respirable suspended particulate (RSP). The raw data for each pollutant, usually measured in micrograms (μg) per cubic meter within a given period of time (one hour, eight hours, twenty-four hours), is turned into a subindex calibrated so that an index of 100 will correspond with a density of pollutant that is dangerous to health. That reading of 100 corresponds to different densities for different pollutants. For instance, for SO_2, an index of 100 is calibrated to 800 micrograms per cubic meter of air (800 μg/m3) in a one-hour period, while for NO_2, the 100 is calibrated to 300 μg/m3. For the general Hong Kong API, the highest of the five subindices (measured in different locations) for a given hour or day is taken as the API for that hour or day.

The clarity of the number 100—so metric!—in the index is what grabbed my attention; it brought to mind the history of the kilogram.[33] In 1799, in an effort to standardize measurements in France, the French National Assembly decreed that a "kilogram" would be defined as the mass of a decimeter of water at four degrees Celsius. Brass and platinum weights were made with equivalent mass, and the platinum one, called the Kilogramme des Archives,

would eventually become the standard mass for twenty other countries in Europe through a treaty known as the Convention du Mètre. A more durable copy of the Kilogramme des Archives, made of platinum and iridium, was later fashioned as the international standard and called "K." Twenty copies of K were then apportioned to each of the signatories of the Convention du Mètre. Was this 100 of the API a universal measure, like the kilogram, calibrated across national and cultural difference through an ultimate standard?

It seems so at first. Common methods and machines internationally unite those who seek to measure air's load. These methods and machines serve as paths of translation; along them air can be turned into vials of dust, which can in turn be transformed into indices. These are "circulating references"—organizations and transformations of matter that allow material to assume more mobile forms.[34] The reversibility of these translations ensures the indices' stability and rigor, assuring their users and proponents of a pathway back to the dust. It takes an apparatus of techniques and methods—not simply the calibration of danger to the integer 100, but also the replicability and reversibility of the translations between air and number—to qualify Hong Kong's API as an index among others. There is a standardization, then, to the techniques for measurement, as well to the form of the API.

When I reviewed the air pollution indices of several other countries, however, I was surprised to find that an API of 100 is calibrated to different amounts of dust in different places. For instance, for carbon monoxide the one-hour objective in Hong Kong is 30,000 μg/m³, while in California the equivalent objective is 23,000.[35] If the air in California had 24,000 μg/m³ of CO in it in a one-hour period, the API would read over 100 and be considered unhealthy, while in Hong Kong the API might hover only around 80 and be considered acceptable.[36] Between the final API form and the standard methods for measurements lies a space for governing what will register as risk or danger.

Most striking is the difference in objectives for RSP (PM_{10}). The twenty-four-hour target in Hong Kong is 180 μg/m³, while the federal standard in the United States is 150. The California standard is lower still, at 50 μg/m³, which is the same as levels deemed acceptable by the World Health Organization (WHO).[37] The Hong Kong threshold at which the air is considered to contain an unhealthy level of RSP is almost four times greater than the threshold in California. The standards for danger are different in different places.

Calibrating the API is a technique for managing the public perception of risk—for a public that includes vendors like Mrs. Chau, sick entrepreneurs like Fred Chan, corporations like Disney, and residents weighing arguments that a more democratic government could care better for its people.[38] The API can be read alongside the adjustment of risk thresholds that Joseph Dumit analyzes in the context of pharmaceutical marketing, where marketers aim to lower the published thresholds so that more people will feel unwell and, therefore, fit for medication.[39] It also has resonances with the novel iterations of data in environmental informatics explicated by Fortun.[40] Together these examples illuminate a common situation in which the ongoing tuning, tweaking, and reiterating of numbers, graphs, and maps becomes central to affective and aesthetic work—the making visible and experienceable (or invisible and unexperienceable) of risks that are difficult to articulate.[41] A symptomless biomarker becomes felt as disease, an intuited tie between social difference and health verges on presence. Through the API's calibration, the smell of diesel drifts in then out, a breath feels alternately thick and thin, clean and dirty, invigorating and debilitating. It is not simply that the API is deployed for persuasive ends, but that the technical practice of its generation—as much as commentaries on the breeze, held breaths, and treatises on the effect of southerly versus northerly winds—brings air into sense and sensibility. This is an aesthetic technology with serious stakes.

Air's Poetics

First of all the enveloping hot air, ungiving,
with not a
flicker of movement, a still thermal from
which there is no
relief. You are surrounded by hot air,
buoyed up by hot air,
weighed down by hot air. You inhale hot
air, you swallow
hot air, you feel hot air behind the ears,
between the legs,
between the toes, under the feet.
Many hours later, a very slight stir,

followed by the
suggestion of a breeze. The thermal
remains.
Yet more hours later, a sudden tearing gust
of wind, and
the storm has arrived.
—Louise Ho, "Storm"

What kind of substance is Hong Kong's air? One shared, particular, and comparable, one realized in bodily, sensory, practical engagements of breath and movement, as well as through the material and mathematical transformations of medical method. One fixed in the whorls between buildings, mobile as it blows across town, across borders, across disciplines—one that signals a global political economy, postcolonial anxiety, as well as concerns about health and well-being.

Air's qualities are coupled with Hong Kong's industries. Think of the smokestacks of industrial factories making goods and the cargo ships moving freight; the carbon footprints of the jets and taxis moving finance workers; the mark on the air from the coal- and gas-burning power plants that send electricity to Hong Kong's skyline and to the electronics shops, bursting with gleaming toys to be bought and powered with leisure money or credit. Think of the combustion at the end of consumption's life cycle, where discarded things are incinerated. Air pollution is both condition and effect of capital. We burn in making, we burn in consuming, we burn in discarding, and the smoke has nowhere to go but up. Once up, this smoke constitutes its own threat to Hong Kong's place in financial circuits.

Hong Kong doctors, meanwhile, work to locate their concerns about the atmospheric load in Hong Kong within broader concerns about health, as well as within international science. Pedestrians and environmentalists worry about the winter shift in the wind that brings China's air into Hong Kong. Air's capacity to hold many forms of substance helped solidify a village–NGO collaboration mobilized to halt construction of an incinerator in Hong Kong's New Territories.

Air disrespects borders, yet at the same time is constituted through difference. Neighborhoods have different atmospheres; nations generate and apply different pollution standards; leaders worry about the state of their air compared to others. The winds themselves derive from differences in air

pressure between regions, and similar relativities allow our lungs to inhale and exhale. Gradients, whose foundations are the contact and bleeding of difference, move air through the spaces we live in and through our bodies.

• • •

How do we theorize this shifting substance bound up in processes of production and consumption that also holds and touches much more? What manner of thinking about scales, distinctions, and connections does it open to us? My answers to these questions remain preliminary, but let me outline for now an argument for air's potential to reorient discussions of political universalism.

Recent efforts in post-Marxist political philosophy to retheorize universalism can be brought fruitfully to bear in the analysis of air, but they also meet a limit. As exemplars of such efforts, consider the interventions made by Butler, Laclau, and Žižek in *Contingency, Hegemony, Universality*.[42] The authors in this exchange agree that there are no obvious political or ethical universals unstained by particularity, and that the concepts of the universal and the particular are best understood in relation with each other and with their deployment in historically specific political acts. On the question of how precisely to understand the relation of the universal and the particular, however, the authors differ strongly.

For Laclau, the universal is an "impossible and necessary object" in the constitution of any political articulation, in both theoretical and political terms. "From a theoretical point of view," he argues, "the very notion of particularity presupposes that of totality . . . And, politically speaking, the right of particular groups of agents—ethnic, national or sexual minorities, for instance—can be formulated only as *universal* rights."[43] The particular is thus for Laclau never outside of, or prior to, a field of relative and necessary universality within which particulars come to be known as such. The universal, in its very impossibility and necessity, grounds the politics (and analytics) of particularity.

Butler, meanwhile, argues almost the reverse point. "If the 'particular' is actually studied in its particularity," she writes, "it may be that a certain competing version of universality is intrinsic to the particular movement itself."[44] That is, a close study of particular political movements might reveal that they actually refigure the universals that they seemed to rely upon.

Universality, for Butler, rather than simply preceding the particular, is in fact generated and iterated through particular visions of the universal.

Žižek, following Hegel and Marx, invokes the concepts of oppositional determination and the concrete universal to solve the paradox of the universal and particular's simultaneity. Of all species within a genus, he argues, there is always one that is both member of the genus and determiner of the terms defining that genus. Furthermore, the historically specific condition of global capital structures the situation of political particularisms; and class politics, he maintains, while one among multiple forms of politics, serves as the model for politics in general.

Any of these positions could ground air's analysis to good effect. We might lean upon Butler's concept of "competing universalities" to argue that the daily mortalities substantiated by Hong Kong's doctors not only buttress a universalizing claim of air pollution's link with dying, but also instantiate a particular, competing version of this universality that questions the peripheralization of Hong Kong scientists and Hong Kong health in international science. We could borrow a page from Žižek to argue that in air's entanglement with capital we encounter the air relation determining all other air relations. Or, twisting somewhat Laclau's characterization of the relation between universalism and contingently articulated political blocs, we could see air emerging as an empty yet always necessary universal—to be filled in with honghei, RSP, typhoons, buses, breezes, science, flies—making environmental politics, rather than class politics, a primary field for political claims.

Before long, however, air would push back. Each approach offers a theory of politics through a solution to the universal/particular paradox; but to do so each leans upon an initial opposition between the universal and the particular to render their coexistence paradoxical in the first place, in need of a solution. As I hope to have conveyed, however, air's encompassment of universal and particular does not present itself as a paradox. It is a banality. Rather than a solution to a paradox of scale, then, air asks for a theoretical language that does not find its movement through multiple scales and political forms remarkable in the first place.

Can we, following Kuriyama, learn to hear air whistling through the hollows of theory? Doing so means making permeable the grounding distinction drawn between the unruly manifold of matter and putatively prior conceptual forms.[45] For ethnography, it also means adopting a different re-

lationship than usual with the concrete. Listening to air, thinking through this diffuse stuff in the thick of becoming, requires less literal materialism.

This reminds me of the remarks of Charles Bernstein, a poet and theorist of poetics, on the relation between poetry and philosophy: "Poetry is the trump; that is to say, in my philosophy, poetry has the power to absorb these other forms of writing, but these other forms do not have that power over poetry. . . . When I think of the relation of poetry to philosophy, I'm always thinking of the poeticizing of philosophy, or making the poetic thinking that is involved in philosophy more explicit."[46] Thinking, for Bernstein, is always a poetic act. Poetry is always thinking. This figuring of always poeticized philosophy pushes me to make explicit the poetic thinking involved in theorizing problems of universality and scale.[47] What are the "universal" and "particular" but conventionalized figures for theory's poetics? Their ossification should be clear when those most ardently debating their definition declare the inadequacy of their terms, and then return to rest on them again and again. Some tropic invigoration might help—a poetic revival through the activation of examples, where details yield not simply particularity but the potential for mobile metaphors. Might the material poetics of the substantiations of Hong Kong's air—with its whirlings, its blowing through scales and borders, its condensations, its physical engagements, its freight of colonial, economic, and bodily worries about health and well-being, its capacity to link and to divide, its harnessing for simultaneously local and cosmopolitan projects—provide that reviving breath theory needs?

STEVEN VOGEL

Life in Moving Fluids

THE PHYSICAL BIOLOGY OF FLOW

SECOND EDITION
REVISED AND EXPANDED
ILLUSTRATED BY
SUSAN TANNER BEETY
AND THE AUTHOR

PRINCETON UNIVERSITY PRESS
PRINCETON, N.J.

Relative Motion

Another matter ought to be set straight at the start, an item that arises with some frequency among biologists taking their first look at fluid flow. Frames of reference can be chosen for convenience, and the surface of the earth upon which we walk has no absolute claim as a "correct" reference frame. One might imagine that a seed carried beneath a parachute of fluffy fibers will trail behind the fibers as the unit is blown across the landscape by a steady wind. In fact the image is quite wrong for anything beyond the initial events of detachment from the plant—when the surface of the earth is still an active participant—as can be seen in Figure 1.1. Farther along (if the wind is steady) neither any longer "knows" anything about what the ground's doing so the seed hangs below the fluff—the surface of the earth now constitutes a reference frame that's both misleading and unnecessarily complex. People who've traveled in balloons commonly comment on the silence and windlessness they experience and its incongruence with clear visual evidence that the ground is moving beneath.

A more drastic if less commonly observed case is that of a "ballooning" spider. (For a general account of the phenomenon, see Bishop 1990.) A young spider spins a long silk strand that extends downwind from it. Eventually it lets go and drifts along. One might expect that the spider is thereafter pulled behind the silken line until the whole system settles to the earth. What will happen in the absence of gusts, vortices, and gradients is that the spider will fall downward but at a speed that's much reduced by the drag of the line. The line will gradually shift from running horizontally to running vertically, forming a relatively high drag, low weight element that extends *downstream* (here, of course, *upward*) from the falling spider. The line lags behind, slowing descent as a result of its high drag relative to its weight. (Humphrey 1987 estimates that the line has over 75% of the drag of the system while contributing less than a tenth of a percent of the weight.)

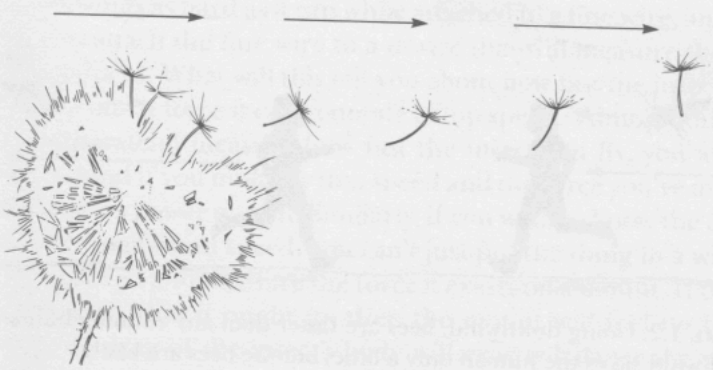

FIGURE 1.1. A dandelion seed carried by a steady wind orients vertically, as if falling through still air. Only during detachment does the fibrous end tilt downwind.

CHAPTER 3

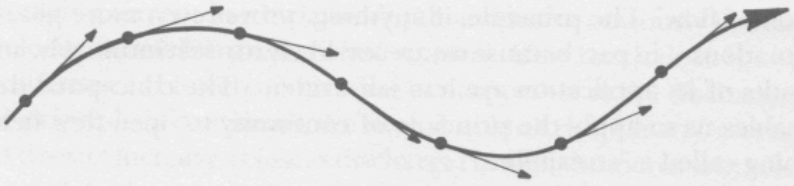

FIGURE 3.5. A streamline (thick line) can be drawn from information about the local direction of flow (arrows) since it's always tangent to the local flow.

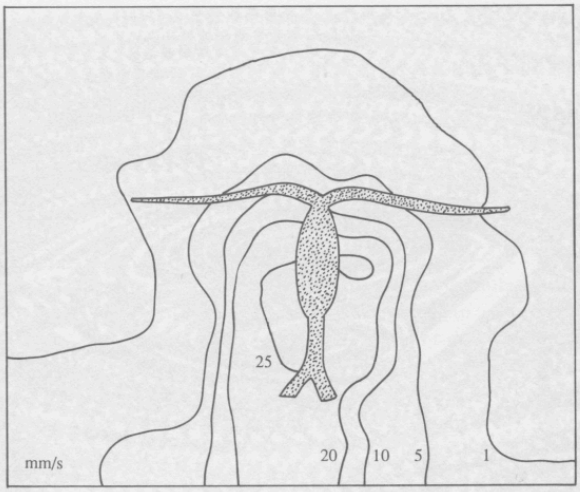

FIGURE 3.8 Isotachs for flow around a swimming copepod (a microcrustacean), *Pleuromamma xiphias*, made by David Fields and Jeannette Yen. The animal is about a millimeter long and is swimming upward.

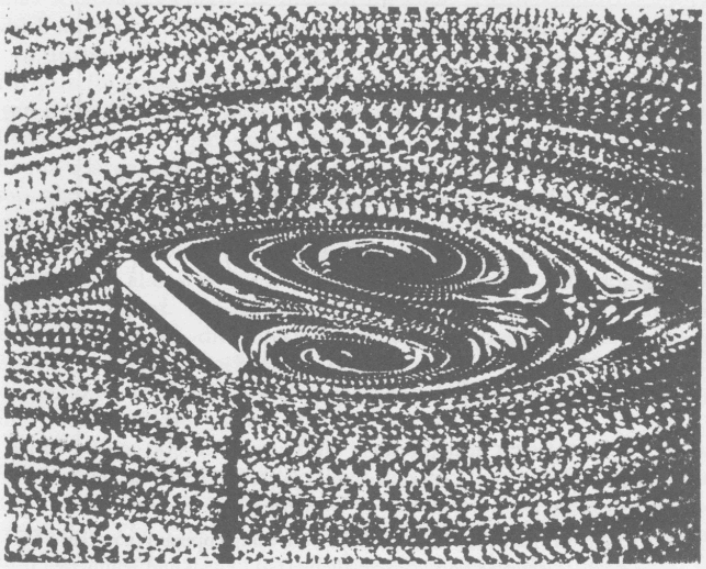

FIGURE 3.7. Pathlines around an inclined flat plate immersed in a rotating bowl of water in which particles have been suspended. The plate was 8.5 mm across, and the rate of flashing of the stroboscope was 12 s^{-1}.

The Aerocene Family

Aerocene is an open project initiated by artist Tomás Saraceno. Aerocene is comprised of a dedicated and diverse global community of artists, geographers, philosophers, thinkers, speculative scientists, explorers, balloonists, technologists, and dreamers. The Aerocene project's primary collaborators and supporters are the Center for Art, Science & Technology (CAST) at the Massachusetts Institute of Technology (MIT), CNES (French National Space Agency), CCK Argentina, Public Lab, The Goethe Institute, Radioamateur, Freifunk, and IAK architecture-related Art Institute at Technische Universität Braunschweig, TBA21, among others. Anyone is invited to share, collaborate, and perform actions in the communal creation and development of the new Aerocene age.

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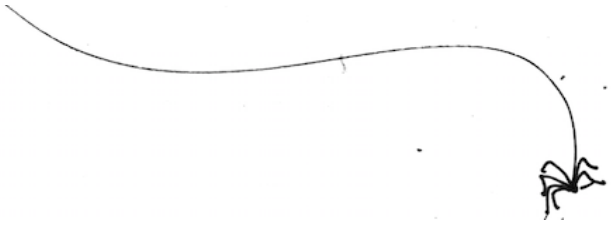

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